New Nouveau
Brunswick

Information Circular 91-2

Project Summaries for 1991

Sixteenth Annual Review of Activities

Compiled and Edited by

Shasta A. Abbott

Natural Resources and Energy

Mineral Resources

Information Circular 91-2

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Project Summaries for 1991

Sixteenth Annual Review of Activities

This report has been prepared by:

Mineral Resources
Department of Natural Resources and Energy
Province of New Brunswick

Hon. Alan R. Graham
Minister of Natural Resources and Energy

Hon. Doug Tyler
Minister of State for Mines and Energy

November, 1991

New Nouveau
Brunswick

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MINISTER OF NATURAL RESOURCES AND ENERGY

Hon. Alan R. Graham, MLA Kent Centre

Alan Robert Graham was born in Main River, New Brunswick on June 20, 1942. He is the son of Harrison M. Graham and Nellie H. Ross.

Mr. Graham was educated at Main River and graduated from Richibucto High School. He has taken several courses in accounting through extension.

A businessman involved in the lumber, transportation, farming and export industries, Mr. Graham has been self-employed for the past 25 years.

First elected to the Legislative Assembly to represent Kent County in the 1967 election, he was reelected in 1970. After redistribution, he was the first member elected to represent the new single-member riding of Kent Centre in 1974. He was reelected in 1978, 1982, and again on October 13, 1987.

Mr. Graham has served on Standing Committees on Agriculture; Contingencies; Economic Development; Energy; Estimates; Forestry and Natural Resources; Law Amendments; Legislative Administration; Municipalities; Natural Resources and Fisheries; Procedure, and Public Accounts. He served on the Select Committees on Agriculture and Renewable Resources; Maritime Affairs; Mining and Nonrenewable Resources, and Renewable Resources. He is a former Critic of the Agriculture, Natural Resources, Housing, and Alcohol and Drug Dependency portfolios, as well as caucus chairman.

Mr Graham served as Minister of Agriculture from 1987 to Oct. 8, 1991.

Sworn in as Minister of Natural Resources and Energy on October 9, 1991, Mr. Graham now serves on the Policy and Priorities Committee. In the past, he also served on several cabinet committees including Budget, Communications, Environment and Sustainable Development Policy, Economic Development, and Economic Committee on Logging and Silviculture sectors, and on Aboriginal Affairs and the Joint Committee of Ministers and Chiefs.

A former 4-H Member, he is a member of the Rexton Lions Club and the Masonic Lodge. He is past director of the credit union, the Kent County Industrial Commission and various co-op movements and farm groups. He was active in the Mentally Retarded Children's Association at the local, provincial and national levels as well as the Canadian Cancer Society.

NOTES

MINISTER OF STATE FOR MINES AND ENERGY

Hon. Doug Tyler, MLA Queens North

Douglas Owen Tyler was born August 19, 1954 in Minto, New Brunswick, the son of Joan and Charles Tyler.

He received his education in the local schools in Chipman. After graduating from Chipman High School, he furthered his education at the Saint John Community College. The recipient of scholastic awards, Mr. Tyler was awarded the Birks Medal for leadership in high school student affairs, and the Saint John Technical School Award for Highest Standard.

A self-employed businessman, Mr. Tyler has been active in the Liberal Party at the local level, and served two terms as president of the Queens North Liberal Association.

He has served on the Legislative Assembly's Standing Committees on Crown Corporations, Estimates, Public Accounts as well as the Special Committee on Economic Policy Development.

Mr. Tyler was sworn in as Minister of State for Mines and Energy on October 9, 1991.

A former executive of the local recreation council and the Kinsman Club, the Royal Canadian Legion Branch #74 and the Grand Lake Region Crime Stoppers. He is actively involved with minor hockey.

NOTES

DEPUTY MINISTER - NATURAL RESOURCES AND ENERGY

M. Mavis Hurley

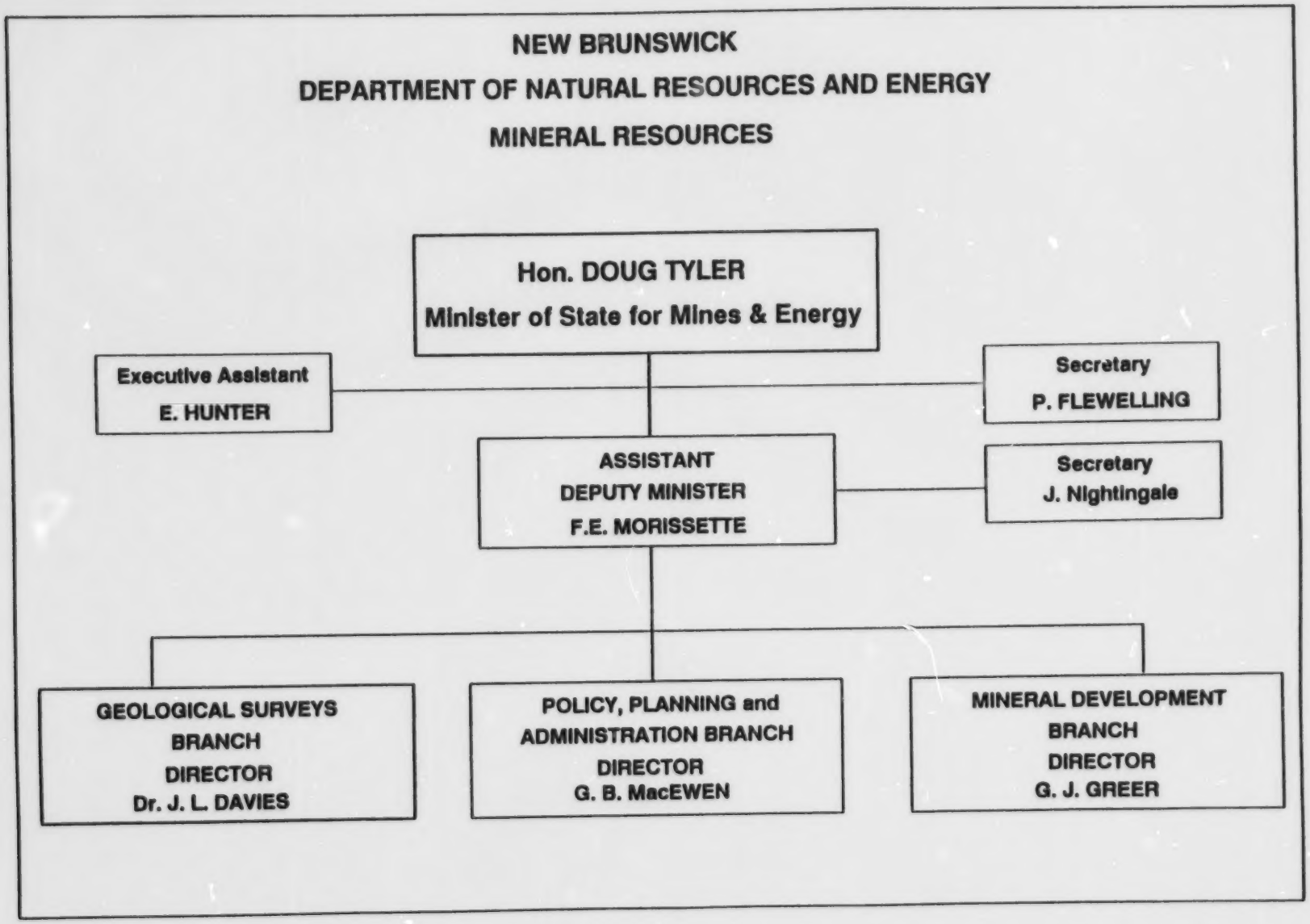
M. Mavis Hurley became Deputy Minister of Natural Resources and Energy on October 9, 1991. She received her university training at the University of New Brunswick (BA, 1965) and at Ottawa University where she earned a Master's Degree in Health Administration in 1973.

She has occupied several posts including Deputy Minister of the Department of Income Assistance, and Deputy Secretary of the Cabinet Committee on Social Policy and Program. She held the positions of Project Team Administrator for the Extra Mural Hospital Program, as well as administrator of a 500-bed hospital in the Province.

NOTES

PART I

MINERAL RESOURCES DIVISION



General organization chart for Mineral Resources

ORGANIZATION OF THE MINERAL RESOURCES DIVISION

INTRODUCTION

New Brunswick has traditional responsibilities for mineral resources it owns and controls. The Mineral Resources Division manages, via a number of Acts, all matters related to mineral exploration, mine development, mineral processing and mine reclamation. The Division promotes the mineral resource potential of the Province and encourages exploration and mining. Furthermore, it strongly supports the preservation of the environment and economic development of the Minerals Sector.

The Division objectives are achieved through related activities of its three branches: Geological Surveys; Mineral Development; and Policy, Planning, and Administration. The budget expenditure supporting these objectives for the 1990-91 fiscal year was $2 975 248. The short-term goals for 1991-92 are to: administer the different mineral/mining acts and promote mineral development; identify and promote the mineral resources potential through geological field research activities, reporting, and mapping; provide policy development, long-term planning, and administration services; strengthen international competitiveness; increase market access; and encourage further processing and value-added products.

The Canada-New Brunswick Cooperative Agreement on Mineral Development (C-NBCAMD), signed in 1990, is managed jointly by the Mineral Resources Division; the Regional Development Commission; Energy, Mines and Resources; and the Atlantic Canada Opportunities Agency. A total of $10 million will by expended over five years based on a cost-sharing formula of 60% Canada/40% New Brunswick. Of the four million dollars earmarked for Division projects, $659 190 was spent in 1990.

The Division clientele are primarily mineral resource companies and associations. As well, many government and paragovernment agencies and other resource-related industries utilize the geoscience information generated by staff as an integral part of the sound management of forest, water, and land resources.

Mr. F.E. Morissette was appointed Assistant Deputy Minister for Mineral Resources. Prior to his appointment, Mr. Morissette was Director, Metals and Minerals, with the Federal Department of Industry, Trade, and Commerce in Ottawa.

GEOLOGICAL SURVEYS BRANCH *(Director, J. Leslie Davies)*

The Geological Surveys Branch is responsible for the collection, interpretation, dissemination, and management of geoscience data in New Brunswick. The Branch goals are to decipher the regolith and bedrock framework of the Province, and to identify the mineral resource potential of the various geological terranes. Closely related activities include; encouraging mineral exploration, promotion of the mineral industry, and advising government on management of mineral, water, and land resources.

The Provincial 'A' budget for 1991/92 is $1.388 million. The amount of field work planned for 1991 was significantly reduced due to a reduction in the number of students that could be hired.

MINERAL DEVELOPMENT BRANCH *(Director, George Greer)*

The Mineral Development Branch is responsible for all activities related to the allocation of mineral rights under the Mining Act and the Quarriable Substances Act; for the utilization of the minerals and quarriable substances in accordance to maximum extraction techniques both in mining and beneficiation; and for the proper reclamation of the disturbed lands. These activities include monitoring the prospecting, exploration, and development stages of the resources as well as reviewing production plans, reclamation plans, and promoting further processing of minerals within the Province. The Branch administers a budget of $678 000 (1991/92) through the following Acts: Mining Act, Quarriable Substances Act, Ownership of Minerals Act, and the Metallic Minerals Tax Act. In addition, the Branch is responsible for acting on decisions under the Peat Policy, Potash Policy, and Coal Policy.

POLICY, PLANNING, AND ADMINISTRATION BRANCH *(Director, Garry MacEwen)*

The Policy, Planning, and Administration Branch is responsible for providing necessary input to policy development and planning. The 1991/92 budget for this branch is $878 800. As well, the Branch provides the economic and financial analysis to develop mineral resource management policies and programs; evaluating federal and other provincial government policies and programmes that affect the management of mineral resources; coordinating the development and administration of federal/provincial mineral development agreements; coordinating legislative, regulatory, and programme initiatives that the Department wishes to carry forward to the Legislature; coordinating geoscientific information and events for public and industry consumption; and providing administrative support to the Mineral Resources Division regarding budgets, staff, and financial information.

CANADA - NEW BRUNSWICK COOPERATION AGREEMENT ON MINERAL DEVELOPMENT (1990-95)[1]

The C-NBCAMD projects summarized within this volume are carried out with the following purpose and objectives. The purpose of this Agreement is to give effect to the ERDA and the objectives as provided therein and more particularly to:

(a) enhance the geoscience database and understanding of the geology of the Province;
(b) support research and development to increase productivity and efficiency of mining and minerals processing, and to address environmental concerns of the industry;
(c) identify, document and promote opportunities for mineral development;
(d) encourage private sector investment in the development of mineral resources in the Province;
(e) enhance the recognition of the role and contribution of both levels of government with respect to the mineral industry, and Agreement activities;
(f) enhance the appreciation and awareness of the mineral sector contribution to New Brunswick.

ORGANISATION DE LA DIVISION DES RESSOURCES MINÉRALES

INTRODUCTION

Le Nouveau-Brunswick a traditionnellement assumé des responsabilités à l'égard des ressources minières qu'elle possède et gère. La Division des ressources minérales administre, en vertu d'un certain nombre de lois, l'exploration minière, l'exploitation des mines, le traitement des minéraux et l'amélioration des mines. La Division s'occupe de promouvoir le potentiel des ressources minérales de la province et elle encourage l'exploration et l'exploitation minière. Elle appuie de plus fortement la préservation de l'environnement et l'essor économique du secteur minier.

La division réalise ses objectifs au moyen des activités connexes de ses trois directions : la Direction des études géologiques, la Direction de l'exploitation des ressources minières et la Direction de la planification et de l'administration. Les dépenses budgétaires permettant de mener à bien cette tâche se sont chiffrées à 2 975 248 $ au cours de l'exercice 1990-1991. Les objectifs à court terme de l'exercice 1991-1992 sont les suivants : administrer les différentes lois régissant les mines/les minéraux et promouvoir l'exploitation minière; déterminer le potentiel en ressources minérales et promouvoir celles-ci grâce à des études géologiques sur le terrain, à l'établissement de rapports et à la cartographie; assurer l'élaboration de politiques, la planification à long terme et les services d'administration; devenir plus concurrentiel sur le marché international; accroître l'accès aux marchés et promouvoir un traitement plus poussé ainsi que les produits de valeur ajoutée.

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[1]The following information is taken from the publication describing the Canada - New Brunswick Cooperation Agreement on Mineral Development (1990-95).

L'Entente de coopération Canada-Nouveau-Brunswick sur l'exploitation minérale, signée en 1990, est administrée conjointement par la Division des ressources minérales, la Commission de développement économique régional, le ministère de l'Énergie, des Mines et des Ressources ainsi que l'Agence de promotion économique du Canada atlantique. On injectera une somme de dix millions de dollars au cours des cinq prochaines années, selon une formule de partage des coûts les imputant à 60 pour 100 au fédéral et à 40 pour 100 à la province. On a dépensé en 1990 659 190 $ des quatre millions de dollars affectés aux projets de la Division.

La clientèle de la Division compte principalement des associations et des entreprises minières. Plusieurs organismes gouvernementaux et paragouvernementaux ainsi que d'autres industries reliées à ces ressources utilisent en outre les données géoscientifiques recueillies par le personnel à titre de partie intégrante de l'aménagement sain des ressources forestières, des eaux et des terres.

M. F.E. Morissette a été nommé sous-ministre adjoint des ressources minérales. Avant d'être nommé à ce poste, M. Morissette était directeur à la section Métaux et Minéraux du ministère fédéral de l'Industrie et du Commerce, à Ottawa.

LA DIRECTION DES ÉTUDES GÉOLOGIQUES

(Directeur : M. J. Leslie Davies)

La Direction des études géologiques est chargé de la collecte, de l'interprétation, de la diffusion et de la gestion des données géoscientifiques au Nouveau-Brunswick. La Direction a pour buts de déchiffrer les structures régolites et les substrats rocheux de la province, et de déterminer le potentiel en ressources minérales des différentes formations géologiques. Les activités étroitement liées à ces tâches comprennent l'encouragement de l'exploration minière, la promotion de l'industrie minière et la prestation de conseils au gouvernement dans le domaine de l'aménagement des ressources minières, des eaux et des terres.

Le budget provincial «A» de l'exercice 1991-1992 se chiffre à 1,388 million de dollars. On a réduit de façon importante la quantité de travail sur le terrain prévue pour 1991 en raison d'une diminution du nombre d'étudiants pouvant être embauchés.

LA DIRECTION DE L'EXPLOITATION DES RESSOURCES MINIÈRES

(Directeur : M. George Greer)

La Direction de l'exploitation des ressources minières s'occupe de toutes les activités liées à l'attribution des droits miniers en vertu de la Loi sur les mines et de la Loi sur l'exploitation des carrières, à l'utilisation des minerais et des substances extraites des carrières conformément aux techniques d'extraction maximales au niveau de l'exploitation et de la concentration, ainsi qu'à la mise en valeur pertinente des terres perturbées. Ces activités comprennent la surveillance des stades de la prospection, de l'exploration et de l'exploitation, ainsi que l'analyse des plans de production et des plans de mise en valeur, et la promotion d'un traitement plus poussé des minéraux à l'intérieur de la province. La Direction administre un budget de 678 000 $ (1991-1992) en vertu des lois suivantes : la Loi sur les mines, la Loi sur l'exploitation des carrières, la Loi sur la propriété des minéraux et la Loi sur les minéraux métalliques. La Direction est en outre chargée de prendre les mesures qu'exigent les décisions découlant des politiques visant la tourbe, la potasse et le charbon.

LA DIRECTION DE LA PLANIFICATION ET DE L'ADMINISTRATION

(Directeur : M. Garry MacEwen)

La Direction de la planification et de l'administration est chargée de fournir l'apport nécessaire à l'élaboration et à la planification des politiques. Le budget de la Direction de l'exercice 1991-1992 se chiffre à 878 800 $. La Direction effectue en outre l'analyse économique et financière permettant d'élaborer les politiques et les programmes du gouvernement provincial; elle évalue les politiques et programmes du gouvernement fédéral et des autres gouvernements provinciaux qui touchent la gestion des ressources minérales; elle coordonne l'élaboration et l'administration des ententes fédérales-provinciales sur l'exploitation minérale; elle coordonne les initiatives législatives et celles ayant trait aux réglementations et aux programmes que le ministère souhaite

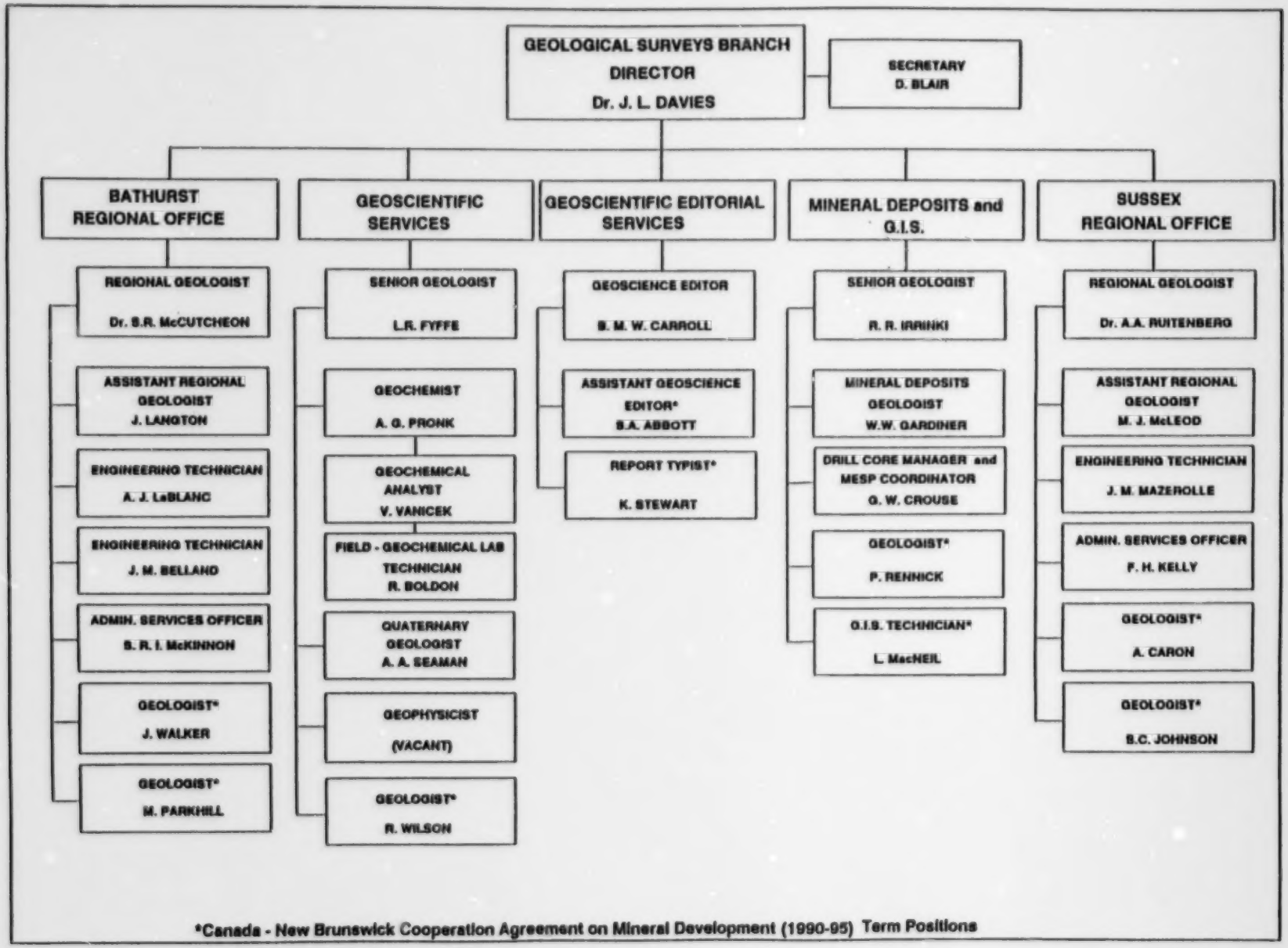
présenter devant l'Assemblée législative; elle coordonne les données géoscientifiques et les activités s'adressant au public et à l'industrie; et elle fournit un soutien administratif à la Division des ressources minérales sur le plan des budgets, du personnel et de l'information financière.

L'ENTENTE DE COOPÉRATION CANADA-NOUVEAU-BRUNSWICK SUR L'EXPLOITATION MINÉRALE (1990-95)

La présente entente a pour but de mettre en application l'EDER et les objectifs qui y sont énoncés et de façon plus particulière:

(a) d'améliorer la base de données géoscientifiques et la compréhension de la géologie de la Province;
(b) de soutenir la recherche et le développement pour accroître la productivité et l'efficacité de l'exploitation minière et de la transformation des minéraux et pour faire face aux préoccupations environnementales de l'industrie;
(c) de définir, documenter et favoriser les perspectives de mise en valeur des minéraux;
(d) d'encourager le secteur privé à investir dans la mise en valeur des minéraux de la Province;
(e) d'accroître la reconnaissance du rôle et de la contribution des deux paliers de gouvernement à l'égard de l'industrie minière et des activités découlant de l'Entente;
(f) d'accentuer l'appréciation et la sensibilisation de la contribution du secteur minier au Nouveau-Bruns...

GEOLOGICAL SURVEYS BRANCH



Organization chart for Geological Surveys Branch

GEOLOGICAL SURVEYS BRANCH

GEOSCIENTIFIC SERVICES SECTION

ACTIVITIES OF THE GEOSCIENTIFIC SERVICES SECTION[2]

L.R. Fyffe
Senior Geologist

The Geoscientific Services staff, located at the Hugh John Flemming Centre in Fredericton, consists of Les Fyffe (Senior Geologist), Allen Seaman (Quaternary Geologist), Toon Pronk (Geochemist), Valeria Vanicek (Geochemical Analyst), and Rex Boldon (technician). Reg Wilson (Project Geologist) carried out a contract mapping project under the Canada-New Brunswick Cooperation Agreement on Mineral Development (C-NBCAMD), 1990-95.

Les Fyffe mapped the bedrock geology of the Flume Ridge – Kedron Stream area (NTS 21 G/6h and 21 G/7e) in Charlotte County to the west of the Mount Pleasant mine. The results of this survey have been digitized onto revised, 1:20 000-scale, computer-generated base maps, which will be on display at the poster session during Open House. Susan Johnson of the Sussex Office is compiling the geology of the Flume Ridge – Kedron Stream area onto 21 G (Scale: 1: 250 000).

Reg Wilson mapped six 1:10 000 map areas (NTS 21 O/8-102, 103, 202, 203, 302, 303) in the Halfmile Lakes – Little Bald Mountain area of Northumberland County. The objective of the study is to gain a better understanding of the physical volcanic environment that favours the formation of massive sulphide deposits in the Bathurst-Newcastle area. Concurrent structural studies are being carried out in the same area by Adrian Park of the UNB Geology Department and Jacob de Roo of the Geological Survey of Canada.

Toon Pronk is supervising the collection of stream-sediment and water samples from the Fosterville (NTS 21 G/13) and Fredericton (NTS 21 G/15) map areas of York County. Allen Seaman and Solweig Balzer, a graduate student at UNB, are mapping and sampling surficial deposits in the Canterbury map area (NTS 21 G/14 of York County. The objective of these geochemical projects is to locate anomalous metal contents along the contact of the Pokiok Batholith, an area favourable for the occurrence of Lake George vein-type deposits (Alain Caron, this volume).

Diane Blair continues to update the computerized and hard-copy files of the Bibliography of New Brunswick Geology maintained within the Mineral Resources Division. There have been approximately 500 new references added since the first publication of the bibliography in 1988 (Geoscience Report 88-1).

Cees van Staal of the Geological Survey of Canada and Les Fyffe prepared a manuscript on the geology of the Dunnage and Gander zones in New Brunswick for publication in the Decade of North American Geology (DNAG) volume, available as NBDNRE Geoscience Report 91-2. Art Ruitenberg and Les Fyffe completed a report entitled: Characteristics and Tectonic Setting of Granitoid Related Mineral Deposits in New Brunswick, Geoscience Report 91-1. Les Fyffe, Malcolm McLeod, and Art Ruitenberg prepared and led a field trip for the New England Intercollegiate Geological Conference (NEIGC) entitled: A Geotraverse Across the St. Croix-Avalon Terrane Boundary, Southern New Brunswick. Les Fyffe and John Riva published a paper entitled "Revised stratigraphy of the Cookson Group of southwestern New Brunswick and adjacent Maine" in Atlantic Geology, **26:** 271-275 (1990). Allen Seaman and Bruce Broster (UNB) published an article entitled "Glacigenic rafting of weathered granite: Charlie Lake, New Brunswick" in Canadian Journal of Earth Sciences, **28:** 649-654 (1991).

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[2]The projects carried out by this section are coordinated with those of the Regional Geologists' in Bathurst and Sussex. The aim of this work is to assess mineral resource potential and encourage mineral resource exploration.

ACTIVITÉS DE LA SECTION DES SERVICES GÉOSCIENTIFIQUES

L.R. Fyffe
géologue senior

Le personnel de la section des services géoscientifiques travaille au centre Hugh John Flemming à Fredericton, et se compose de Les Fyffe (géologue sénior), Allen Seaman (géologue du quaternaire), Toon Pronk (géochimiste), Valeria Vanicek (analyste en géochimie) et Rex Boldon (technicien). Reg Wilson (géologue de projet) a réalisé un projet de cartographie à contrat aux termes de l'Entente de coopération Canada–Nouveau-Brunswick sur l'exploitation minérale (ECCNBEM), 1990-95.

Les Fyffe a cartographié la géologie du substrat rocheux de la région Flume Ridge-Kedron Stream (SNRC 21 G/6h et 21 G/7e), dans le comté de Charlotte, à l'ouest de la mine du mont Pleasant. Les résultats de l'étude ont été numérisés sur des cartes informatisées révisées, à l'échelle de 1/20 000, qui seront exposées lors des séances de démonstration des journées portes ouvertes. Susan Johnson, du bureau de Sussex, effectue en ce moment la compilation des travaux de géologie de Flume Ridge-Kedron Stream sur le secteur géologique 21 G, à l'échelle de 1/250 000.

Reg Wilson a cartographié six secteurs géologiques à l'échelle de 1/10 000 (SNRC 21 O/8-102, 103, 202, 203, 302 et 303) de la région de Halfmile Lakes - Little Bald Mountain, dans le comté de Northumberland. L'étude a pour objectif d'acquérir une meilleure compréhension de l'environnement volcanique physique favorisant la formation de gisements de sulfures massifs, dans la région de Bathurst-Newcastle. Adrian Park, du Département de géologie de l'U. du N.-B., et Jacob de Roo, de la Commission géologique du Canada, entreprennent simultanément des études structurales de la même région.

Toon Pronk supervise le prélèvement d'échantillons d'eau et de sédiments fluviatiles des secteurs géologiques de Forestville (SNRC 21 G/13) et de Fredericton (SNRC G/15) dans le comté de York. Allen Seaman et Solweig Balzer (étudiant diplômé de l'U. du N.-B.) effectuent des travaux de cartographie et d'échantillonnage sur les gisements superficiels du secteur géologique de Canterbury (SNRC 21 G/14), dans le comté de York. Ces projets géochimiques visant à localiser les teneurs métalliques anormales le long de l'auréole de métamorphisme du batholite de Pokiok, région favorable à la venue de gisements filoniens du lac George (Alain Caron, présent volume).

Diane Blair poursuit la mise à jour des fichiers informatisés et des copies papier des fichiers de la bibliographie sur la géologie du Nouveau-Brunswick maintenue au sein de la Division des ressources minérales. Environ 500 nouvelles références ont été ajoutées depuis la première publication de la bibliographie en 1988 (rapport géoscientifique 88-1).

Cees van Staal, de la Commission géologique du Canada, et Les Fyffe, ont préparé un manuscrit sur la géologie des zones de Dunnage et de Gander au Nouveau-Brunswick en vue de sa publication dans le volume «Decade of North American Geology» (Décennie de la géologie nord-américaine) (DNAG), offert à titre de rapport géoscientifique 91-2 du MRNE du N.-B. Art Ruitenberg et Les Fyffe ont terminé un rapport intitulé «Characteristics and Tectonic Setting of Granitoid Related Mineral Deposits in New Brunswick», Geoscience Report 91-1 (Caractéristiques et compaction tectonique des gisements minéraux granitoïdiques au Nouveau-Brunswick, rapport géoscientifique 91-1). Les Fyffe, Malcolm McLeod et Art Ruitenberg ont préparé et dirigé une excursion sur le terrain à l'intention de la «New England Intercollegiate Geological Conference» (NEIGC) intitulée «A Geotraverse Across the St-Croix Avalon Terrane Boundary, Southern New Brunswick» (Vue d'ensemble géologique de la limite de formation géologique de Sainte-Croix-Avalon, au sud du Nouveau-Brunswick). Les Fyffe et John Riva ont publié, dans Atlantic Geology, 26:271-275 (1990), un document intitulé «Revised stratigraphy of the Cookson Group of Southwestern New Brunswick and Adjacent Maine» (Stratigraphie révisée du groupe de Cookson au sud-ouest du Nouveau-Brunswick et dans le Maine adjacent). Allen Seaman et Bruce Broster (U. du N.-B.) ont publié, dans le Journal canadien des sciences de la terre, 28:649-654, un article intitulé «Glacigenic rafting of weathered granite: Charlie Lake, New Brunswick» (Chevauchement glacigénique du granit décomposé : lac Charlie, Nouveau-Brunswick).

GEOLOGY OF THE FLUME RIDGE-KEDRON STREAM MAP AREAS, CHARLOTTE COUNTY, NEW BRUNSWICK[3]

L.R. Fyffe
Senior Geologist

The bedrock geology of the Flume Ridge-Kedron Stream area in northern Charlotte County, New Brunswick was mapped at 1:20 000 scale during the summer of 1991. The stratigraphic correlation of two sequences previously considered part of the Waweig Formation is revised based on the results of this survey. A thick-bedded, feldspathic wacke sequence in the eastern part of the area is now assigned to the Late Ordovician/Early Silurian Digdeguash Formation and a sequence of calc-silicate beds, intervening between the Digdeguash Formation and overlying calcareous rocks of the Silurian Flume Ridge Formation, is included in the newly established Sand Brook Formation.

Mineralization in the Flume Ridge-Kedron Stream area is apparently related to two distinct episodes of granite emplacement. Tin and zinc occur within the roof zone and contact aureole of equigranular, lithian mica-bearing granites, whereas tin and tungsten are associated with a higher level stock of biotite microgranite porphyry.

Au cours de l'été 1991, la géologie du dépôt rocheux de la région de la rivière Flume Ridge-Kedron, dans le nord du comté de Charlotte, au Nouveau-Brunswick, a été soumise à des travaux cartographiques à l'échelle de 1/20 000. La corrélation stratigraphique de deux paragénèses considérées antérieurement comme partie intégrante de la formation de Waweig est révisée en fonction des résultats de cette étude. Une paragénèse de wackstone-feldspath à dépôts épais dans la partie est de la région, est maintenant attribuée à la formation de Digdeguash de l'Ordovicien supérieur-Silurien inférieur, et une paragénèse de dépôts à silicate de calcium, interposée entre la formation de Digdeguash et recouvrant des roches calcaires de la formation silurienne de Flume Ridge, est incluse dans la formation nouvellement établie du ruisseau Sand.

La minéralisation de la région de la rivière Flume Ridge-Kedron est apparemment reliée à deux épisodes distincts d'intrusion de granit. L'étain et le zinc apparaissent à l'intérieur de zone de couverture et de l'auréole métamorphique de granits isogranulaires à muscovite lithologique, tandis que l'étain et le tungstène sont associés à un stock de porphyre à biotite microgranitique.

INTRODUCTION

Two adjacent, 1:20 000 map areas in northern Charlotte County, New Brunswick, comprising the Flume Ridge map area in the west (NTS 21 G/6h of the 1:50 000 Rollingdam map sheet) and Kedron Stream map area in the east (NTS 21 G/7e of the 1:50 000 McDougall Lake sheet) were surveyed in the summer of 1991 (Figure 1). This mapping is a continuation of a project that began four years ago to study the stratigraphy, structure, and metallogeny of Ordovician through Devonian rocks in southwestern New Brunswick. Other maps previously completed under this program include NTS 21 G/13e, f; 21 G/6b, c, d, e; and 21 G/11c, d, e. These effectively extend coverage from the St. Croix River on the New Brunswick border, eastward to the Mount Pleasant mine (Fyffe 1989, 1990*a*, 1990*b*; Fyffe and Riva 1990). Geological revisions to the east of Mount Pleasant are reported by McLeod *et al.* (1991).

LITHOLOGICAL UNITS

Ruitenberg (1967) was the first to subdivide the stratigraphic sequence within the Flume Ridge-Kedron Stream area. Quartz-rich wackes in the west, which he referred to as the Digdeguash Formation, were interpreted to interfinger eastward with feldspathic wackes that were correlated with the shallower water, Silurian Waweig Formation exposed in the Oak Bay area near St. Stephen. Both the quartz-rich and feldspathic wackes were shown to be gradationally overlain by calcareous siltstones of the Flume Ridge Formation. The present

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[3]This project augments the geocompilation program being carried out by A.A. Ruitenberg *et al.* on 21 H and 21 G (this volume)

FIGURE 1. Tectonostratigraphic terranes and cover sequences of New Brunswick with location of the Flume Ridge–Kedron Stream area. The Elmtree and Miramichi terranes are, respectively, Early Ordovician oceanic crust and ensialic volcanic rocks generated in a back-arc setting. The St. Croix Terrane is an Ordovician sedimentary clastic wedge presumably deposited off the margin of the Avalonian Terrane. The Avalonian Terrane comprises Precambrian volcanic and sedimentary rocks. The Matapédia, Fredericton, and Mascarene cover sequences are sedimentary and volcanic rocks that were deposited unconformably on the older terranes between the Late Ordovician and Early Devonian. FAULTS: 1 = Jacquet River Fault; 2 = Rocky Brook-Millstream Fault; 3 = Portage Lakes-Serpentine River Fault; 4 = Catamaran Fault; 5 = Woodstock Fault; 6 = Bamford Brook-Hainesville Fault; 7 = Fredericton Fault; 8 = Basswood Ridge and Pendar Brook faults; 9 = Falls Brook-Taylor Brook Fault; 10 = Belleisle-Wheaton Brook Fault.

study suggests, however, that the wackes in the eastern part of the area should also be included in the Digdeguash Formation with any lithologic variation being attributable to lateral facies changes expected within a deep-marine, turbiditic succession. In addition, an intervening sequence characterized by green and maroon siltstone beds, referred to here as the Sand Brook Formation, has been recognized to lie between the Digdeguash and Flume Ridge formations (Figure 2).

The Digdeguash Formation is comprised largely of medium grey, medium- to thick-bedded feldspathic wacke interstratified with dark grey slate. Thicker bedded sections (70 cm to 1 m thick) appear to possess a higher feldspar to quartz ratio (3:2 compared to 4:1) and a lower proportion (less than 20%) of interbedded slate than thinner bedded sections (10 to 50 cm thick). Thicker beds locally grade downward to a coarse grit containing abundant rock fragments, whereas thinner beds grade upward into a dark grey siltstone. Sole marks were observed on the base of a thick wacke bed exposed on the Magaguadavic River below Pomeroy. In order of abundance, the wackes contain angular quartz grains, feldspar, volcanic and granophyric fragments, and muscovite flakes set in a silty matrix comprising approximately 50 per cent of the rock. Thick-bedded, light grey quartz wackes, which occur locally in the southern part of the area, contain single and polycrystalline grains of quartz set in a 15 per cent silty matrix. The Digdeguash Formation is unfossiliferous, but is assigned a Late Ordovician/Early Silurian age on the basis that it underlies the probable Silurian Flume Ridge and Sand Brook formations and overlies the Early to mid-Ordovician Cookson Group (Ruitenberg 1967; Ludman 1991).

The Sand Brook Formation is a newly recognized unit that lies stratigraphically between the Digdeguash and Flume Ridge formations. The type-section is located about 25 km west of the Flume Ridge-Kedron Lake area (Figure 3), within the contact aureole of the Magaguadavic Granite, where its calc-silicate composition is reflected in the presence of metamorphic pyroxene. An excellent section of the Sand Brook Formation is exposed along Piskahegan Stream in the Flume Ridge-Kedron Lake area.

The Sand Brook Formation comprises 2 cm- to 1 m-thick beds that grade upward from light green feldspathic wacke to a laminated green and maroon siltstone top about 5 cm thick. Although commonly present as laminations, the maroon siltstone locally attains bed thicknesses from 2 to 20 cm. A conspicuous slump fold with a wavelength of 30 cm, observable 700 m upstream from the Piskahegan bridge during low water levels, indicates a downslope direction toward the northwest. Wackes of the Sand Brook Formation contain a higher feldspar to quartz ratio (about 1:1) and less matrix (typically 15% compared to 50%) than wackes of the Digdeguash Formation. The abundance of epidote and actinolite, indicative of a calc-silicate composition, is responsible for the light green colour of the Sand Brook Formation in contrast to the grey colour of the Digdeguash Formation.

Although absent from the Piskahegan section, dark grey slate becomes a significant component of the Sand Brook Formation on strike to the west along the Magaguadavic River and Cox Brook (Figure 2). Still farther west along Jones Brook (just west of the Flume Ridge-Kedron Lake area), light green beds typical of the Sand Brook Formation are absent and the Flume Ridge Formation lies directly on dark grey wackes of the Digdeguash Formation (Figure 4). It thus appears that the Sand Brook Formation thins by interfingering westward with the upper part of the Digdeguash Formation, whereas it thickens eastward toward Mount Pleasant and the Sand Brook area (Figure 3). The lower contact between the Sand Brook and Digdeguash formations on Piskahegan Stream and Magaguadavic River appears to be conformable and rather abrupt, although one thin calc-silicate bed was observed within the Digdeguash Formation just below where the contact has been placed along the Magaguadavic River. The Sand Brook Formation is considered to be Early Silurian in age, since it grades conformably upward into the Flume Ridge Formation.

The Flume Ridge Formation typically comprises light grey, thin- to medium-bedded (5-15 cm thick), fine-grained, micaceous, calcareous wacke and siltstone interstratified with light to medium grey, non-calcareous slate. The calcareous wacke beds contain approximately 40% calcite, 30% quartz, 5% feldspar plus muscovite, and 25% silty matrix. Local sequences of well-graded, non-calcareous, lithic wacke in beds up to 25 cm thick, separated by 5-cm–thick beds of non-calcareous siltstone, contain abundant volcanic fragments. Within a few metres of its contact with the underlying Sand Brook Formation, the Flume Ridge Formation contains alternating thin beds of calcareous and non-calcareous wacke; the contact with the Sand Brook Formation is placed at the base of the lowest calcareous bed.

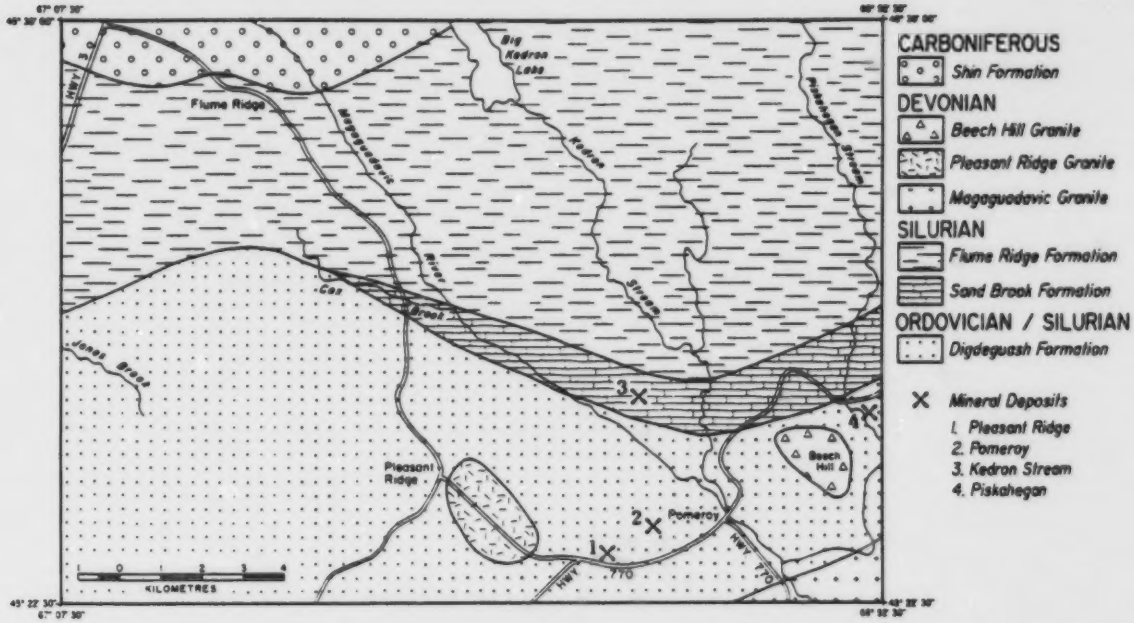

FIGURE 2. Bedrock geology of the Flume Ridge–Kedron Stream map area.

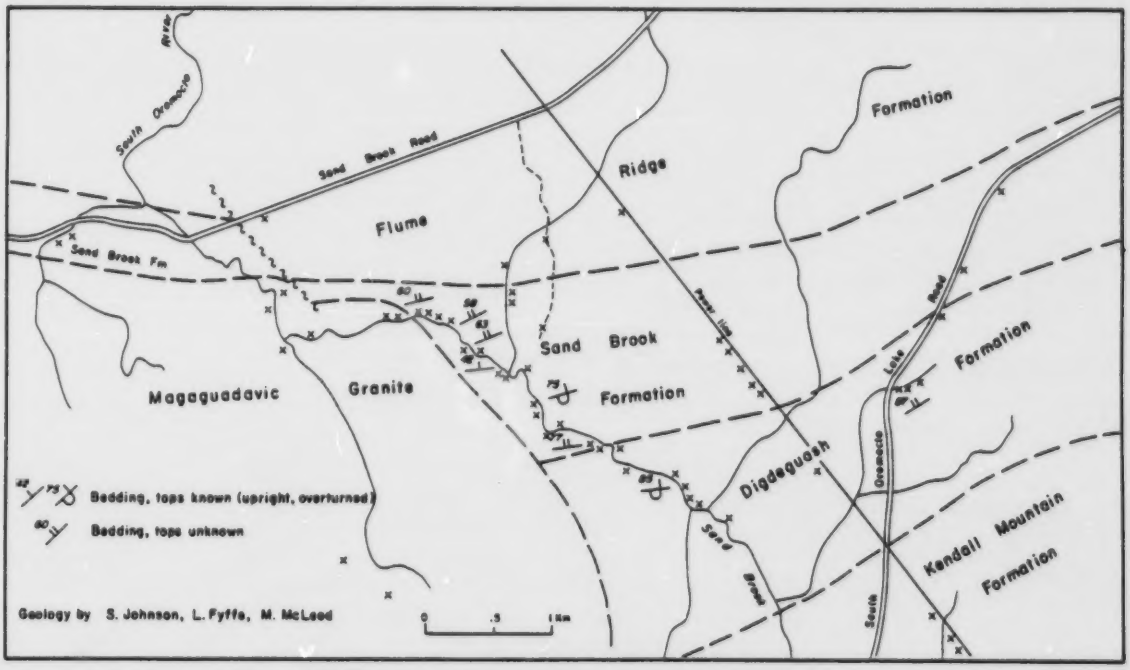

FIGURE 3. Bedrock geology of the Sand Brook area.

Bailey and Matthew (1872) assigned a Devonian age to the Flume Ridge Formation on the basis of supposed plant fragments found along Cox Brook. However, examination of an original specimen stored at the Saint John Museum, together with similar specimens recovered this year on Cox Brook, reveals that they are dark grey slate chips within calcareous wacke. The slate chips are spotted due to incipient metamorphism giving them the scaled appearance of plant fragments. The Flume Ridge Formation is considered here to be Silurian in age because of the gradational nature of its contact with graptolite-bearing wackes of the Silurian (Wenlock to Ludlow) Burtts Corner wackes farther to the northwest (Fyffe 1989).

Thick-bedded, greenish grey, polymictic conglomerate interbedded with minor red arkosic sandstone unconformably overlies the Flume Ridge Formation in the northwestern corner of the map area. Angular clasts of vein quartz and pebbles of Flume Ridge wacke are abundant in the conglomerate. The presence of a few large clasts of felsic volcanic rocks, presumably derived from the Mount Pleasant area, suggests a correlation with the Carboniferous Shin Formation of the Piskahegan Group (van de Poll 1967).

Light pink, megacrystic, biotite granite exposed near the mouth of Piskahegan Stream (Figure 2) is part of the Magaguadavic Granite, which constitutes a 300 km^2 pluton in the northwestern portion of the Saint George Batholith (McLeod 1990). The megacrysts (up to 5 cm in length) are predominantly alkali feldspar with lesser plagioclase. Radiometric dating of zircon yielded an Early Devonian (396±1 Ma) age of emplacement (Bevier 1990). The sedimentary country rocks of the Digdeguash Formation exhibit prominent porphyroblasts of andalusite and cordierite and a significant increase in quartz veining within 1 km of the contact.

The Beech Hill Granite forms a small, subcircular stock about 1.5 km in diameter intruding the Digdeguash Formation in the southeast corner of the Flume Ridge-Kedron Stream area (Figure 2). The granite-country rock contact, exposed along the powerline, is sharp and steep with narrow granitic veins extending into the hornfelsed sedimentary rocks. A spotted hornfels, containing andalusite, cordierite, biotite, and recrystallized quartz and muscovite, extends approximately 500 m from the contact. The density of quartz veins in the country rocks increases markedly within a kilometre of the contact. A light pink, greisenized porphyry dyke of the Beech Hill Granite, a few metres wide, is exposed just north of the Piskahegan Stream bridge. Light greenish grey, fine-grained, greisenized quartz-feldspar porphyry dykes exposed to the north along Jones Brook, Cox Brook, Magaguadavic River, and Kedron Stream may have been emplaced contemporaneously with the Beech Hill Granite.

The Beech Hill Granite is a dark pink, biotite-feldspar-quartz-phyric microgranite. The ratio of phenocrysts to groundmass varies considerably: the content of quartz phenocrysts ranges from 26 to 35%; alkali feldspar phenocrysts from 7-45%; and plagioclase phenocrysts from 0-44%. This variation is largely attributable to the local concentration of crystals by the mechanism of filter pressing. The texture of the groundmass varies from hypidiomorphic with a 0.1 mm grain size to allotriomorphic with a 0.05 mm grain size. The development of allotriomorphic texture was likely produced by the venting of volatiles to the surface (Butt 1976). A Late Devonian age is assigned to the Beech Hill Granite because it is texturally very similar to the Mount Douglas Granite of the Saint George Batholith (McLeod 1990). The Beech Hill stock presumably represents a cupola of a more extensive pluton extending from Sorrel Ridge in the southwest to Mount Pleasant in the northeast.

An oblong pluton with a surface area of approximately 8 km^2 underlies Pleasant Ridge in the south-central part of the Flume Ridge-Kedron Stream area (Tupper 1959; Ruitenberg 1967). No exposures were seen during the present mapping, but boulders of light grey, equigranular, muscovite-biotite granite are plentiful on Pleasant Ridge. The primary magmatic origin of the muscovite is demonstrated by its interstitial nature and indicates that crystallization took place under higher water pressure and greater depth than the Beech Hill Granite (Butt 1976). The high Li, Rb, and F contents of the Pleasant Ridge Granite suggests that the muscovite is lithian in composition (Butt 1976; Taylor *et al.* 1985). No radiometric ages are available from the Pleasant Ridge Granite, but since it was emplaced at a greater depth than the Late Devonian Beech Hill Granite, it must be a few tens of million years older to allow for erosion and subsequent higher level emplacement of the latter.

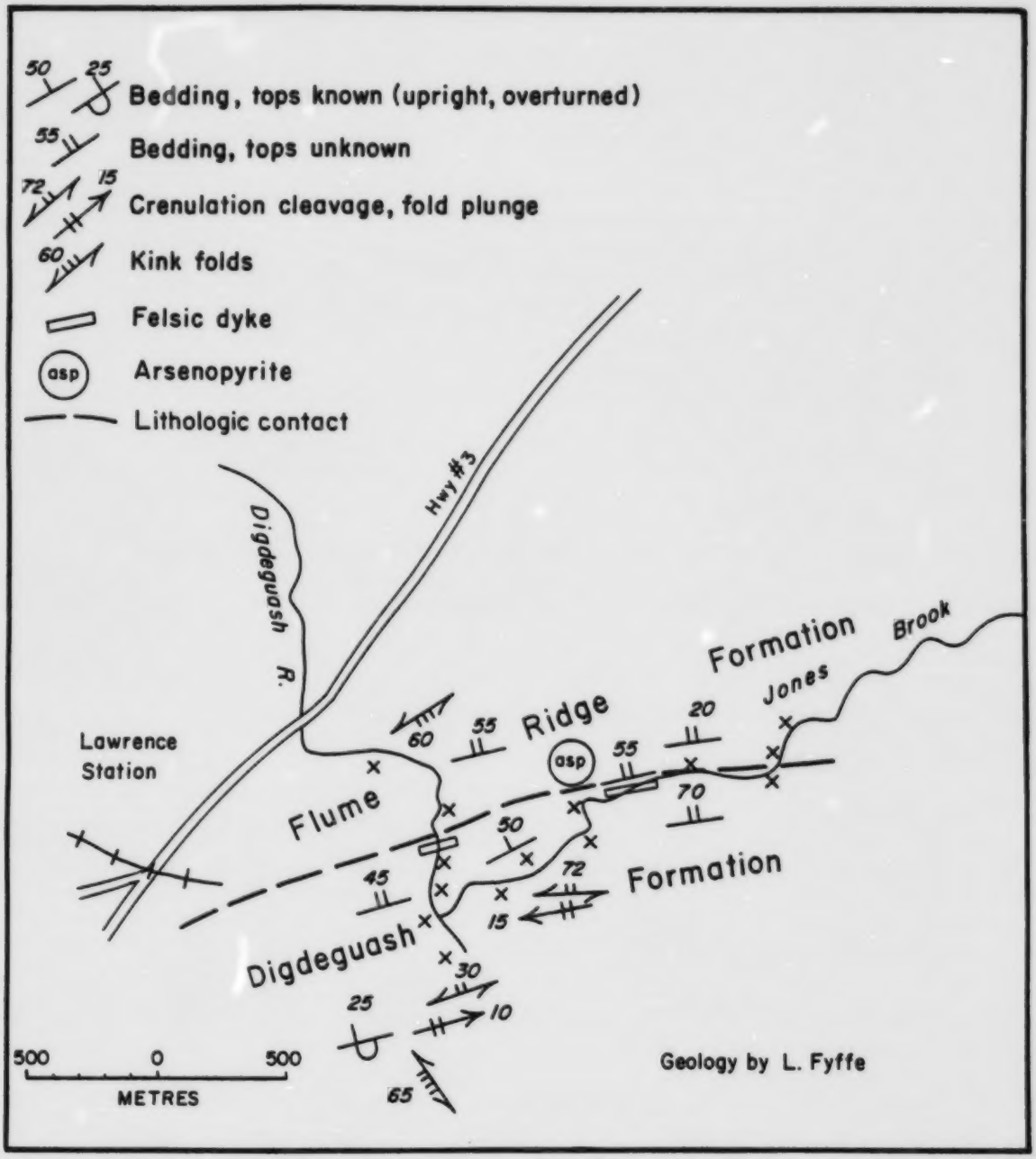

FIGURE 4. Bedrock geology of the Jones Brook area.

STRUCTURE

Bedding and slaty cleavage attitudes in the Flume Ridge Formation are generally steep, but become shallower to the south and consistently north-dipping near the contact with, and within, the Sand Brook and Digdeguash formations. No actual fold closures were noted in the Flume Ridge Formation; the only well-exposed section occurs along the Magaguadavic River below Flume Falls and the fine-grained nature of these rocks precludes the determination of younging direction.

Tight, south-verging folds with associated axial planar cleavage, dipping moderately to the north, are pervasive within the Digdeguash Formation, locally observed within slaty sections of the Sand Brook Formation, but apparently absent from the Flume Ridge Formation. Wavelengths of these folds typically range from 5 to 10 m, so that grading directions in beds vary over short distances. In slaty beds, the axial planar cleavage can be seen to crenulate another cleavage that parallels bedding, suggesting that the pervasive folds are second-generation structures. This has been confirmed in a well-exposed section on Kedron Stream where the facing direction of second folds reverses along the crenulation cleavage over a distance of 3 m, thus demonstrating the presence of an earlier set of recumbent, isoclinal folds.

The rapid change in structural style across, and concentration of felsic dykes along, the northern boundary of the Digdeguash Formation suggest that it may represent a high-strain zone along which some slippage to the south has been accommodated. Where the contact can be observed along Jones Brook (Figure 4), 30 cm of sheared dark grey slate, injected with quartz stringers, separates wackes of the Digdeguash Formation from calcareous siltstones of the structurally overlying Flume Ridge Formation.

East-southeast-trending kink bands, generally dipping steeply to the south-southwest, are common throughout the Flume Ridge-Kedron Stream area, but are particularly conspicuous in the Flume Ridge Formation. Steep north-northwest-trending kink bands are less common and probably formed contemporaneously with megascopic open folding. These folds are responsible for the change in trend of bedding from east-southeast to east-northeast, and corresponding reversal in plunge of second folds from southeast to southwest across the area from west to east. A similar change in trend of greisenized dykes suggests that their emplacement also predated the open folding.

ECONOMIC GEOLOGY

Anomalous tin values were first reported in the Flume Ridge-Kedron Stream area from quartz veins exposed 200 m upstream from the bridge over Kedron Stream (Wright 1940). Since that time, several significant mineral showings have been discovered in the area, all associated with the contact zones of Devonian granites. These include the Pleasant Ridge, Pomeroy, Kedron Stream Road, and Piskahegan Stream occurrences (Figure 2).

Along the southeastern contact of the Pleasant Ridge Granite, 700 m east of the junction of the Flume Ridge Road and Route 770 at Pleasant Ridge (No. 1, Figure 2), drill holes intersected wackes of the Digdeguash Formation, which contained narrow quartz veins assaying 1.05% Sn, 1.5% Pb, and 4.0% Zn (New Brunswick Mineral Occurrence File).

The Pomeroy mineral occurrence (No. 2, Figure 2), exposed in trenches along the powerline about 1.7 km west of the Pomeroy bridge, is hosted by wacke and slate of the Digdeguash Formation. Stringers and disseminations of pyrite, sphalerite, chalcopyrite, and cassiterite are localized along a steep, northwest-trending shear zone flooded with quartz veins up to 5 cm thick. Assays of channel samples indicate that the mineral zone, which has a strike-length of approximate 350 m, has an average grade of 8% Zn and 0.94% Sn over a width of 1.75 m. The best drill-hole intersection assayed 2% Zn and 0.11% Sn over 0.17 m (New Brunswick Mineral Occurrence File).

Tin mineralization at the Kedron Stream Road showing, 2 km northwest of the Kedron Stream bridge (No. 3, Figure 2), is associated with a partially unroofed cusp (approximately 100 m in diameter) of a buried granite stock that intrudes wackes and siltstone of the Sand Brook Formation. The surrounding country rocks

are metamorphosed to a skarn for several metres from the contact and hydrothermally brecciated at the contact. Pervasive quartz-topaz-lithian muscovite-fluorite greisen was intersected beneath the silicified zone and passes gradationally into unaltered fine-grained equigranular granite at a depth of about 100 m. The granite is chemically similar to the lithian muscovite-bearing granite at Pleasant Ridge. The silicified zone assayed up to 300 ppm Sn, and the underlying greisen zone, up to 2000 ppm Sn. A narrow quartz vein in the cusp contains arsenopyrite, pyrite, chalcopyrite, molybdenite, cassiterite, and anomalous gold and silver values (Taylor *et al.* 1985).

Grab samples of silicified wackes taken from drill-hole intersections along the northeast contact of the Beech Hill stock, assayed up to 0.13% Sn and 0.77% WO_3 (No. 4, Figure 2).

During the recent mapping, chalcopyrite and pyrite in quartz float were noted on a logging road to the southeast of the Pleasant Ridge occurrence. Crystals of arsenopyrite were also observed in narrow quartz veins cutting a greisenized felsic dyke on Jones Brook (Figure 4).

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GEOCHEMISTRY[4]

Toon Pronk
Geochemist

FIELD ACTIVITIES

Stream-sediment and water samples were collected in the Fosterville (21 G/13) and Fredericton (21 G/15) map areas to complete the survey over the main part of the Pokiok Batholith and adjacent rocks. Data for 21 G/11, 12, and 14 have been received from the geochemical laboratories, but are not ready for release at this time. Further delay may justify releasing the data as one set of five NTS sheets next summer. Financial restraints, which necessitated a cutback in student manpower, have delayed completion of the project. The field crew for this project was led by our technician Rex Boldon.

Sampling of selected sites overlying major bedrock formations to establish baseline geochemistry information continued in cooperation with Peter Friske (GSC). Some detailed stream-sediment, water, and till sampling over the Halfmile Lake area took place recently in cooperation with Mike Parkhill from our Bathurst office.

LABORATORY ACTIVITIES

core samples from the Carboniferous drilling project are being analysed for Cu, Pb, Zn, Ag, Mn, Co, and Ni on a continuing basis. These results will augment data previously obtained from a limited selection of core samples. The geochemical file will be updated when the work is completed. Till samples from several projects (S.A. Balzer, M.A. Parkhill, A.A. Seaman), are analysed for base metals in our laboratory by Valeria Vanicek using Atomic Absorption.

Sample preparation, mostly sieving, and some cutting and pulverizing takes place in our lab on tills, stream sediments, and rocks. Heavy minerals are being concentrated from archived till samples using gold wheel, shaker table, and heavy liquid separation. This work is performed by students, who want to extend a summer job into a thesis or senior report. Cooperation is required from the student's supervisor. Ed Hornibrook, who worked on the Trout Brook - Todd Mountain area last year (Hornibrook 1991), carried out a similar project for the Millville area this summer. The objective of these projects is to delineate heavy mineral dispersion patterns, estimate transport distance and direction, and then apply this information to exploration efforts in those areas. Areas are selected in consultation with our mineral deposits geologist, Bill Gardiner.

Archiving samples from our own surveys, and others (*e.g.*, GSC till sampling program) is an important ongoing responsibility of our laboratory personnel.

OTHER ACTIVITIES

On January 23, Toon Pronk attended a meeting in Ottawa (in conjunction with the GSC Forum) of the Working Group on Regional Geochemical Mapping, followed by a meeting of the IGCP 259 on International Geochemical Mapping. Standardisation in methodology, database accessibility and compatibility, and multiple use of data were the main topics of discussion.

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[4]Geochemical surveys are carried out primarily to aid mineral resource exploration by private industry. The results of such surveys indicate broad areas of relatively high mineral resource potential encouraging exploration companies and prospectors to examine them in more detail. The results of regolith surveys provide valuable information for forest-site classification. Priority, however, is given to regions considered to have a relatively high mineral resource potential. Although chemical analysis is still performed in the geochemical laboratory, the emphasis of the work is on sample preparation.

On February 9, at the Atlantic Geoscience Society symposium on environmental geology, Mr. Pronk gave a presentation with a New Brunswick perspective. From groundwater issues to forest management, hazard mapping, and energy-related issues; geology lies at the base, and thus the title "Geology and Environment; Earth First?". He also presented an extended version of this paper to UNB's environmental geology class. This presentation will be published at a later date in Atlantic Geology.

During 1991 Mining Week (May 27-31), our applied geology display was set up in malls in both Campbellton and Fredericton. Public response was above expectation. Earlier the display was used to promote earth science to teachers at the Energy and Environmental Educators of New Brunswick (EENB) in Saint John. The display was used throughout the year for career days (Fredericton High, George Street Jr. High), science fairs (Park St. and McAdam Ave. Schools, Fredericton), and even a geology day (Andover Elementary). It was used for schools ranging from elementary to senior-high level; generally, oral presentations and rock displays accompanied the display.

From June 2-7, T. Pronk co-chaired the 1991 biennial meeting of CANQUA, the Canadian Quaternary Association, in Fredericton, which was co-sponsored by the UNB Geology Department (Dr. B.E. Broster) and the Mineral Resources Division. The meeting was attended by 65 Quaternarists from Canada and the USA. One of the highlights of the meeting was a public lecture by Dr. A.V. Morgan (University of Waterloo, on secondment to the GSC Global Change Program) entitled "Global Change, a major challenge for the next century". The subsequent field trip held in southwestern New Brunswick was very successful.

GÉOCHIMIE

Toon Pronk
Géochimiste

ACTIVITÉS SUR LE TERRAIN

Des échantillons de sédiments fluviatiles et d'eau ont été prélevés dans les régions cartographiques de Fosterville (21 G/13) et de Fredericton (21 G/15) afin de compléter l'étude de la partie principale du batholite de Pokiok et des roches adjacentes. Des données pour les feuilles topographiques 21 G/11, 12 et 14 ont été obtenues des laboratoires de géochimie, mais elles ne sont pas encore prêtes à être publiées. Un retard supplémentaire pourrait justifier la publication, l'été prochain, des données en un seul jeu de cinq feuilles du SNRC. Les contraintes financières, qui ont exigé qu'on réduise la main-d'oeuvre étudiante, ont retardé l'achèvement du projet. L'équipe sur le terrain de ce projet a été dirigée par notre technicien Rex Boldon.

L'échantillonnage de sites sélectionnés recouvrant d'importantes formations de dépôts rocheux en vue de l'obtention de renseignements de base en géochimie s'est poursuivi avec la collaboration de Peter Friske (SGC). Quelques échantillonnages détaillés de sédiments fluviatiles, d'eau et de moraines de la région de Halfmile Lake ont été effectués avec la collaboration de Mike Parkhill, de notre bureau de Bathurst.

ACTIVITÉS EN LABORATOIRE

L'analyse des échantillons de carottes de forage prélevés grâce au projet de forage du Carbonifère se poursuit. Pendant la compilation des données, plusieurs trous et sections de trous n'ont révélé aucune donnée nous incitant à poursuivre le projet. Valeria Vanicek analyse, dans nos laboratoires, les échantillons de moraines de plusieurs projets (S.A. Balzer, M.A. Parkhill, A.A. Seaman), pour déterminer leur teneur en métaux communs, par la méthode de l'absorption atomique.

La préparation des échantillons, principalement le tamisage, et une part de fragmentation et de pulvérisation, est effectuée dans nos laboratoires sur les moraines, les sédiments fluviatiles et les roches. Les minéraux lourds sont concentrés à partir des échantillons de moraines en archives au moyen de la séparation

par roues d'or, par table vibrante et par liquide dense. Ce travail est exécuté par des étudiants qui souhaitent profiter d'un travail d'été pour préparer une thèse ou un rapport principal. La collaboration du surveillant des étudiants est essentielle. Ed Hornibrook qui a travaillé, l'année dernière, sur la région du ruisseau Trout-du mont Todd (Hornibrook 1991), a réalisé, cet été, un projet similaire pour la région de Millville. Ces projets ont pour objectif de délimiter des modèles de dispersion de minéraux lourds, d'évaluer la distance et la direction de transport, puis d'appliquer cette information aux efforts d'exploration de ces régions. Les régions sont choisies en consultation avec notre géologue aux gisements minéraux, Bill Gardiner.

L'archivage des échantillons de nos propres études, et d'autres études (*p. ex.*, le programme d'échantillonnage des moraines de la SGC) constitue une responsabilité permanente importante de notre personnel de laboratoire.

AUTRES ACTIVITÉS

Le 23 janvier, Toon Pronk a assisté, à Ottawa, à une réunion (conjointement avec le Forum de la CGC) du Groupe de travail sur la cartographie géochimique régionale, suivie d'une réunion du PICG 259 (Programme international de corrélation géologique) sur la cartographie géochimique internationale. La normalisation de la méthodologie, l'accessibilité et la compatibilité des bases de données, ainsi que l'utilisation multiple des données ont été les principaux sujets de discussion abordés.

Le 9 février, au colloque de l'Atlantic Geoscience Society sur la géologie environnementale, Pronk a donné une présentation avec une perspective du Nouveau-Brunswick. Depuis les eaux souterraines aux questions reliées à l'aménagement des forêts, à la cartographie des régions inondables et à l'énergie, la géologie demeure une science de base, et c'est pourquoi on avait choisi le titre «Geology and Environment; Earth First?» (La géologie et l'environnement : La Terre d'abord?). Il a également présenté une version complète de ce document à la classe de géologie environnementale de l'Université du Nouveau-Brunswick. Cette présentation sera publiée à une date ultérieure dans «Atlantic Geology».

Au cours de la Semaine de l'industrie minière de 1991 (du 27 au 31 mai), notre présentoir de géologie appliquée a été installé dans des centre commerciaux de Campbellton et de Fredericton. La réponse du public a dépassé nos espérances. Le présentoir avait auparavant servi à promouvoir les sciences de la terre auprès des enseignants au colloque Éducateurs en matière énergétique du Nouveau-Brunswick (ÉÉNB), à Saint-Jean. Le présentoir a été utilisé tout au long de l'année pour les journées d'orientation professionnelle (Fredericton High School, école élémentaire George Street), pour les foires des sciences (écoles de la rue Park et de l'avenue McAdam, Fredericton), et même pour une Journée de la géologie (École élémentaire d'Andover). Le présentoir a servi à des écoles des niveaux élémentaire et secondaire; en général, des présentations orales et des expositions de roches accompagnaient le présentoir.

Du 2 au 7 juin, T. Pronk a coprésidé la biennale de CANQUA 1991, L'Association canadienne pour l'étude du Quaternaire, à Fredericton, qui a été coparrainée par le Département de géologie de UNB (B.E. Broster) et par la Division des ressources minières. Soixante-cinq quaternaristes venus du Canada et des États-Unis ont assisté à la réunion. L'un des faits saillants de la réunion a été la conférence publique intitulée «Transformation du globe : Un défi pour le siècle suivant», donnée par A.V. Morgan (Université de Waterloo, affecté à titre provisoire au Programme de transformation du globe de la GSC). L'excursion sur le terrain qui a eu lieu dans le sud-ouest du Nouveau-Brunswick s'est avérée un franc succès.

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QUATERNARY GEOLOGY: 1991 ACTIVITIES[5]

A.A. Seaman
Quaternary Geologist

In 1991, work was continued on the Southern Pokiok Batholith project, begun in 1990. The objective of this project is to map the surficial geology (regolith) of the southern Pokiok Batholith and adjacent area, and obtain samples of till for geochemical analysis (using a 2-km grid spacing). The study area comprises the New Brunswick parts of the McAdam (NTS 21 G/11), Forest City (NTS 21 G/12), and Fosterville (NTS 21 G/13) map areas, and all of the Canterbury (NTS 21 G/14) map area (Figure 5). The area includes the Lake George antimony mine (presently inactive), plus a significant component of the St. Croix International Waterway. This program complements ongoing bedrock mapping and stream-sediment geochemistry programs in the area.

In 1990, field work was carried out in the Forest City map area (Seaman 1990) and in the eastern half of the Canterbury map area (Balzer 1990). Reductions in the A-base budget resulted in a reduced field program for 1991. Mapping and sampling of the Canterbury map area was completed by Solweig Balzer, with assistance from Allen Seaman (see the following report). However, the completion of mapping and sampling of the Forest Planning Zone of the St. Croix International Waterway area, planned for this year, has been deferred to 1992. This planning zone encompasses the New Brunswick portion of the Forest City map area in addition to parts of the Canterbury, Fosterville, and McAdam map areas. Allen Seaman carried out a limited amount of mapping and sampling in this zone, specifically around Fifth, Sixth, and Palfrey lakes, in the northwestern corner of the McAdam map area.

On June 3 and 4, 1991, the University of New Brunswick hosted the biennial CANQUA (Canadian Quaternary Association) conference. The topic of the conference was "Late Glacial and Post-glacial Events in Coastal Environments." Allen Seaman acted as coordinator for the three-day field excursion that followed the conference (Seaman *et al.* 1991*a*). In collaboration with Toon Pronk and Mike Parkhill, he also presented a paper (Seaman *et al.* 1991*b*) outlining changes in the interpretation of the Quaternary geology of New Brunswick since the publication of Geological Survey of Canada Memoir 416 (Rampton *et al.* 1984). Solweig Balzer, in cooperation with Dr. Bruce Broster of the University of New Brunswick, presented a poster display on glacial dispersion of clasts in the Lake George area, based on her 1990 investigations (Balzer and Broster 1991).

GÉOLOGIE DU QUATERNAIRE : ACTIVITÉS DE 1991

A.A. Seaman
Géologue du quaternaire

En 1991, on a poursuivi les travaux du projet du batholite Pokiok sud amorcé en 1990. L'objectif de ce projet est d'établir une carte de la géologie des formations superficielles (régolite) de la région sud du batholite Pokiok et des endroits environnants ainsi que d'obtenir des échantillons de till aux fins d'analyse géochimique (à des écarts de graticule de 2 km). Le secteur étudié comprend les parties des secteurs cartographiques de McAdam (NTS 21 G/11), de Forest City (NTS 21 G/12) et de Fosterville (NTS 21 G/13) du Nouveau-Brunswick, ainsi que tout le secteur cartographique de Canterbury (NTS 21 G/14) (Figure 5). Le secteur comprend la mine d'antimoine du lac George (présentement inactive) et une partie importante de la voie navigable internationale de St. Croix. Ce programme complète la cartographie permanente du substrat rocheux et les programmes de géochimie des sédiments fluviatiles dans le secteur.

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[5]Quaternary (regolith) mapping is an ongoing program involving "A" base and C-NBCAMD funds. The results are useful in the search for mineral resources, reforestation, engineering projects, and the management of groundwater resources.

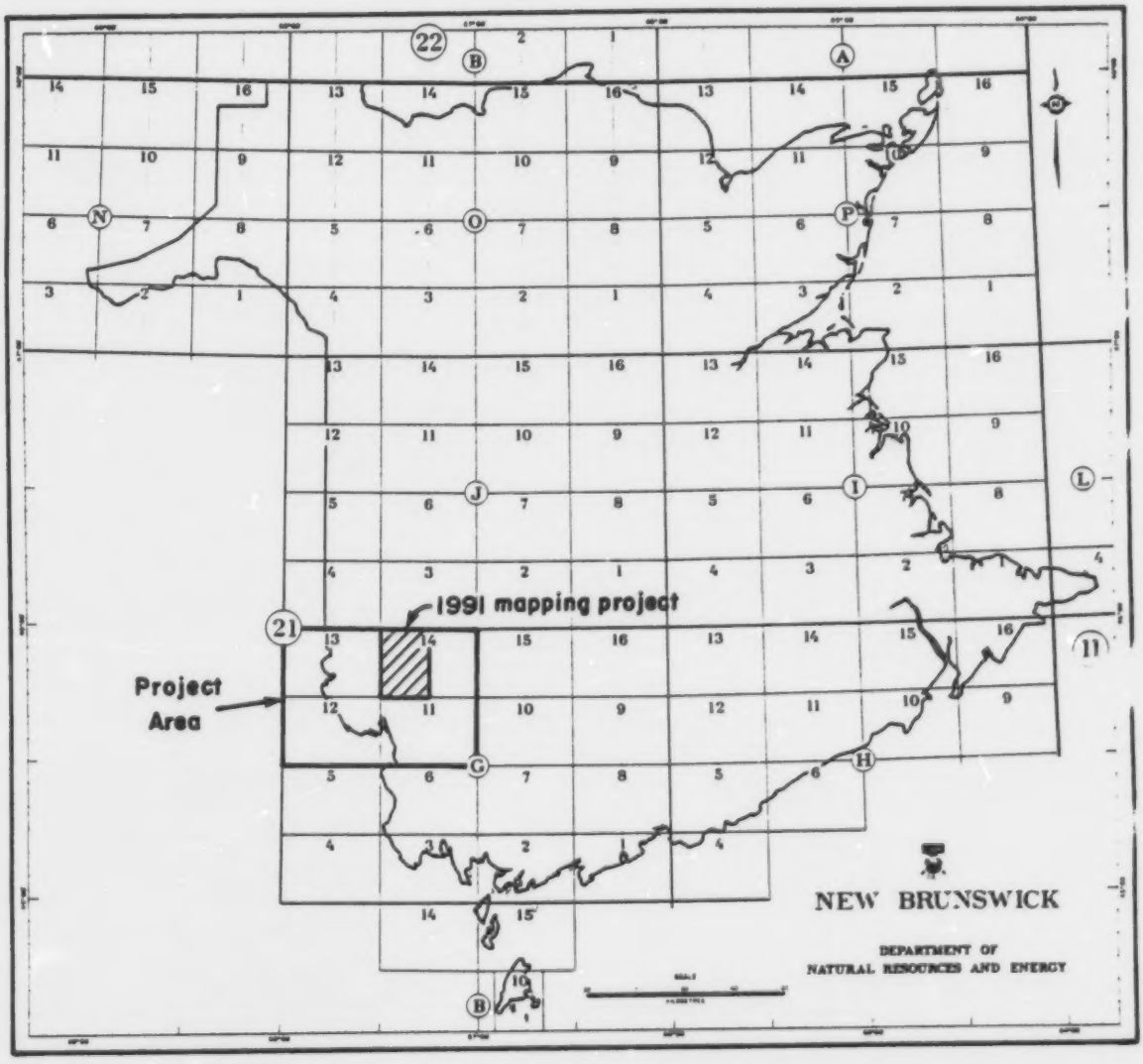

FIGURE 5. Index map to Southern Pokiok Batholith project area including parts of the McAdam (NTS 21 G/11), Forest City (NTS 21 G/12), and Fosterville (NTS 21 G/13) map areas, and all of the Canterbury (NTS 21 G/14) map area.

En 1990, on a entrepris des travaux sur le terrain dans le secteur cartographique de Forest City (Seaman 1990) et dans la moitié est du secteur cartographique de Canterbury (Balzer 1990). Des réductions dans le budget de base A ont entraîné une diminution du programme sur le terrain en 1991. Solweig Balzer a terminé, avec l'aide de Allen Seaman, la cartographie et l'échantillonnage du secteur cartographique de Canterbury (voir le rapport suivant). La cartographie et l'échantillonnage de la zone de planification forestière de la région de la voie navigable internationale de St. Croix, prévue pour cette année, a cependant été remise à 1992. Cette zone de planification renferme la partie néo-brunswickoise du secteur cartographique de Forest City ainsi que des parties des secteurs cartographiques de Canterbury, de Fosterville et de McAdam. Allen Seaman n'a entrepris qu'un peu de cartographie et d'échantillonnage dans ce secteur, particulièrement autour des lacs Fifth, Sixth et Palfrey, dans la partie nord-ouest du secteur cartographique de McAdam.

Les 3 et 4 juin 1991, l'Université du Nouveau-Brunswick était hôte du congrès biennal CANQUA (Association canadienne pour l'étude du quaternaire). La conférence avait pour thème «les événements tardiglaciaires et post-glaciaires des milieux côtiers». Allen Seaman a agi à titre de coordonnateur de l'excursion de trois jours qui a suivi la conférence (Seaman *et coll.* 1991*a*). En collaboration avec Toon Pronk et Mike Parkhill, il a également présenté un document (Seaman *et coll.* 1984) donnant les grandes lignes des changements survenus dans l'interprétation de la géologie quaternaire au Nouveau-Brunswick depuis la publication du mémoire 416 de la Commission géologique du Canada (Rampton *et coll.* 1984). Solweig Balzer a présenté, en collaboration avec le Dr Bruce Broster de l'Université du Nouveau-Brunswick, une exposition d'affiches sur la dispersion glaciaire des clastes dans le secteur du lac George, d'après ses études de 1990 (Balzer et Broster 1991).

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QUATERNARY GEOLOGY AND DISPERSAL PATTERNS OF THE CANTERBURY MAP AREA (NTS 21 G/14), YORK COUNTY, NEW BRUNSWICK[6]

S.A. Balzer
Graduate Student, University of New Brunswick

Several till facies and glaciofluvial deposits cover much of the Canterbury map area (NTS 21 G/14). Till facies are defined based on textural and lithological properties with respect to the underlying bedrock. Facies changes occur over relatively short distances. Esker/outwash complexes and kames in the area show paleocurrents trending to the south and east. Thick exposures of grus overlying the granite are common, and some show evidence of glaciotectonic deformation. Erosional indicators of ice flow show strong movement to the south and southeast and may be topographically controlled.

Plusieurs faciès de till et de gisements fluvio-glaciaires recouvrent une grande partie du secteur cartographique de Canterbury (NTS 21 G/14). Les faciès de till sont définis selon leur texture et leurs propriétés lithologiques par rapport au substrat rocheux sous-jacent. Les passages de faciès se produisent sur des distances relativement courtes. Des complexes d'eskers et d'épandages fluvio-glaciaires ainsi que des kames dans le secteur montrent des paléocourants vers le sud et vers l'est. Des affleurements d'arènes épaisses recouvrent communément le granite et certaines d'entre elles contiennent des preuves de déformations glaciotectoniques. Les indicateurs d'érosion du flux des glaces indiquent un déplacement prononcé vers le sud et vers le sud-est et ils peuvent être contrôlés topographiquement.

Field mapping and sampling of Quaternary sediments in the Canterbury map area (NTS 21 G/14) was undertaken during the summers of 1990 and 1991 (Figure 5). A total of 270 sites were sampled on a 2-km grid. Detailed mapping at one-kilometre intervals was performed to fill gaps produced by the grid system and to determine the effect of lithologic dispersion across bedrock boundaries.

Several till facies and various glaciofluvial deposits have been identified. Till facies can be subd visually, into four "basal" and two "ablation" types based on texture, clast content, and underlying bedroc The term facies is used to reflect the frequent changes seen in the tills over short distances. These units ran from a thin veneer to several metres in thickness.

A silty-sandy to sandy granitic basal facies occurs in close proximity to swamps and peat bogs over the central part of the map area. Foreign clast content is variable. A thin ablation lag of granite boulders overlies this facies, covering 50-90% of the surface.

The second basal facies overlies the metasediments and volcanics in the western portion of the area. Lithologic complexity of the underlying bedrock is reflected in the variable properties of this facies. The matrix is silty to sandy-silty with colours ranging from brownish grey-tan to green-grey with some tan/brown tinges.

A silty basal facies, with minor clay and sand, overlies the Silurian greywacke to the southwest and south of Lake George. Normally a tan colour with tinges of grey or brown, this facies becomes increasingly mottled toward the east.

The fourth basal unit, a brown sandy-silty facies with tinges of green/tan/purple, occurs north of Lake George. Although local, this facies contains a significant amount of Carboniferous sediment that originates from the outlier to the northwest.

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[6]Quaternary mapping in York County is part of the long-term program to cover the entire Province. Priorities at the moment are placed on regions or areas of high mineral-resource potential. Results of this work are very useful for mineral exploration.

Ablation till-facies are texturally and lithologically variant, with 50-95% of their surfaces covered by boulder lags. Dispersal patterns trending southeast and east, undergo facies changes within short distances. The granitic ablation facies can be traced for only a few kilometres, whereas the metasediment-rich facies can be traced for up to 14 kilometres.

Glaciofluvial deposits, in the form of complex esker/outwash systems and ice-contact kames, occur along the Saint John River and throughout the study area. Most of the esker systems are small, with the exception of Pokiok Road esker, which extends discontinuously from the Saint John River to the southern edge of the map area. Paleocurrents suggest flow in a general south-to-eastward direction.

The distribution of grus is greater than previously noted. Exposures exceeding several metres have been found overlying granite of the Pokiok Batholith. The relationship of the grus to glacial activity in the area is still under investigation. Evidence of glaciotectonism has been documented in two exposures near Charlie Lake (Broster and Seaman 1991).

Alluvium occurs along the Saint John River and in some of its larger coves as small sand bars and barriers. Stratified clay, silt, and sand underlie areas along the river where topography is relatively flat to gently rolling. Low-relief areas with high water tables contain extensive organic deposits of peat and black ooze. Many of the bogs exceed several metres in depth.

Erosional features such as striae, grooves, and roches moutonnées indicate strong south-to-southeastward ice flow. This is comparable to ice directions previously noted by others (Rampton *et al.* 1984). Areas of multiple orientation occur near physiographic obstacles, suggesting that the ice may have been topographically controlled. In some areas, the bedrock appears to be streamlined with thicker deposits of sediments occurring in the troughs.

Till samples will be analysed for their geochemical, lithological, and sedimentological properties. The tests are intended to supply information relating to ice-induced lithological dispersion patterns and ultimately to the glacial history of the area.

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HALFMILE LAKES – HEATH STEELE PROJECT, NORTHUMBERLAND COUNTY, NEW BRUNSWICK (C-NBCAMD)[7]

R.A. Wilson
Project Geologist

Geological mapping of parts of NTS 21 0/8 continued in 1991; six 1/10 000 map sheets (21 0/8-102, 103, 202, 203, 302, and 303) in the Halfmile Lakes – Little Bald Mountain area were completed (Figure 6). The objective of the project is to define stratigraphic relationships and interpret the physical volcanology of volcanic rocks within the southern and southwestern portions of the Bathurst-Newcastle mining camp. This work is intended to complement the ongoing structural studies being carried out by the Geological Survey of Canada, and New Brunswick Geological Surveys Branch personnel. Field work to date has resulted in the examination of roughly 4000 outcrops, and collection of over 2400 rock samples from the 1990 and 1991 field areas. Whole-rock geochemical analyses and extensive petrographic studies of this large inventory of samples will be undertaken to help define stratigraphic units and volcanic facies.

The Halfmile Lakes - Heath Steele project area is underlain by several rock formations that comprise the mid-Ordovician Tetagouche Group. These formations are, from oldest to youngest (though some overlap in time commonly exists between successive units), the Patrick Brook, Nepisiguit Falls, Flat Landing Brook, Canoe Landing Lake, and Boucher Brook formations (van Staal and Fyffe 1991). Quartzose arenites and wackes believed to represent the underlying Miramichi Group are exposed in the southwest part of the survey area near Little Bald Mountain. Upper Silurian intrusive rocks underlie portions of the southwest corner of the survey area, and include the Miramichi biotite granite, and the Goodwin Lake gabbro, which hosts a small Cu-Ni deposit near Maliseet Mountain.

Rocks belonging to the Patrick Brook Formation occur only in the southwest corner near Little Bald Mountain. The Patrick Brook Formation includes lithic sandstone and greywacke (probably epiclastic sediments) and metapelites that overlie quartzose rocks of the Miramichi Group. The Nepisiquit Falls Formation consists of quartz-feldspar-phyric rhyolite flows and intrusive domes and sills (quartz-feldspar porphyry), and equivalent rocks, commonly termed "quartz-feldspar augen schists", found in zones of high strain. Quartz and/or feldspar-bearing, proximal to distal epiclastic rocks are commonly associated with these porphyries. No textural evidence has been found to support the contention of some previous workers that at least some of the quartz-feldspar porphyries have a pyroclastic origin. For example, no pumice is seen, and phenocrysts are normally intact except where tectonically pulled apart; quartz crystals are frequently deeply embayed and unbroken. No bubble-wall shards are evident, and, though these may have obliterated by deformation and metamorphism, the frequent preservation of primary textures such as spherulites and perlitic fractures suggests that shards, if present, should be locally preserved as well.

The Flat Landing Brook formation consists primarily of subaqueous, aphyric or feldspar-phyric rhyolites that often feature perlitic or spherulitic textures indicative of an originally glassy state. Felsic hyaloclastic breccias and microbreccias, and associated epiclastic rocks (hyalotuffs), are interpreted as autoclastic rocks formed by quench-shattering and spalling of the margins of subaqueous glassy rhyolitic flows and domes. These rocks typically contain pink angular felsic fragments in a green, granular chloritic matrix that is interpreted as altered, finely granulated rhyolitic glass. These rocks have previously been interpreted as mafic tuffs and agglomerates; however, their intimate spatial association with massive, spherulitic, or perlitic rhyolites, the pervasive abundance of angular rhyolite clasts, and their similarity in thin section to felsic hyaloclastites noted in Lower Devonian vol-

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[7]Contribution to the Canada - New Brunswick Cooperation Agreement on Mineral Development, 1990-95. Project carried by the Geological Surveys Branch of the New Brunswick Department of Natural Resources and Energy. The aim of this project is to help private industry search for new reserves of zinc-lead-silver-copper ore in the Bathurst-Newcastle mining camp. This report covers the second season of field work. The project will be completed in 1995.

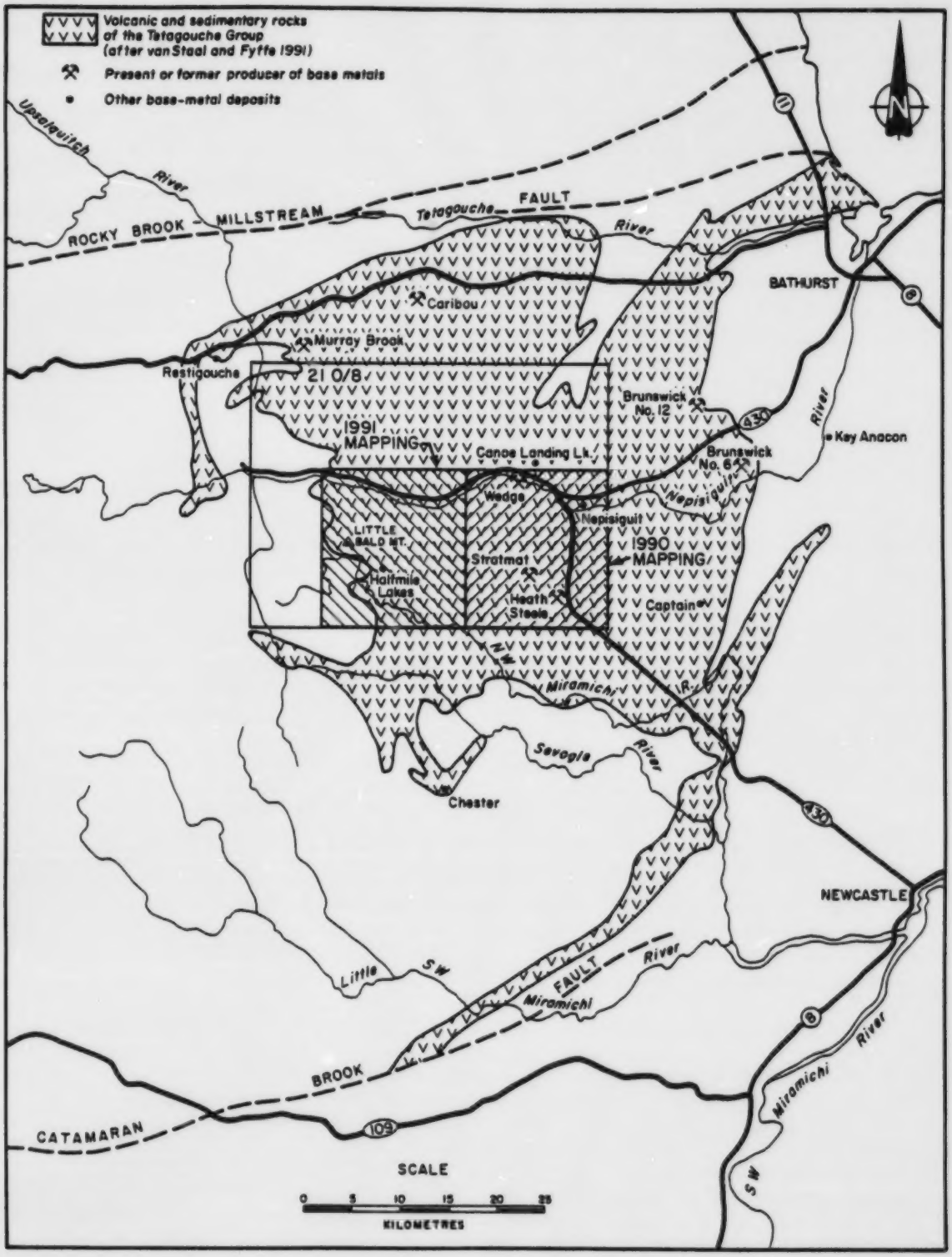

FIGURE 6. Halfmile Lakes – Heath Steele project area, and distribution of Tetagouche Group volcanic rocks.

canic sequences in the Tobique region, suggests that many of these "chlorite fragmentals" have been mislabelled. The Flat Landing Formation also includes local minor epiclastic sedimentary rocks, and tholeiitic basalts and gabbros, *e.g.*, the Otter Brook tholeiite (van Staal and Fyffe 1991).

The Canoe Landing Lake Formation occurs only in the northeast corner of the survey area, and consists of alkalic pillow basalt. The Boucher Brook Formation is lithologically variable in the survey area, consisting mainly of diverse sedimentary rocks, including metawacke or lithic wacke, metasiltstone, slate, metapelite (dark grey to black manganiferous and locally graphitic argillites and mudstones), and dark grey to maroon hematitic and manganiferous slate, siltstone, and chert (so-called RMS unit). Basalt is often intercalated with the sedimentary rocks (Brunswick alkalic basalt - van Staal and Fyffe 1991), and also occurs as a thick unit unaccompanied by sedimentary rocks southeast of Heath Steele Mine.

PROJET LACS HALFMILE — HEATH STEELE, COMTÉ DE NORTHUMBERLAND, NOUVEAU BRUNSWICK (ECCNBEM)

R. A. Wilson
Géologue d'études

Les travaux de cartographie géologique des parties du SNRC 21 O/8 se sont poursuivis en 1991, tandis que six feuilles topographiques à l'échelle de 1/10 000 (21 O/8-102, 103, 202, 203, 302 et 303) ont été terminées (Figure 6) dans la région de Halfmile Lakes-mont Little Bald. Le projet a pour objectif de définir les relations stratigraphiques et d'interpréter la volcanologie physique des roches volcaniques à l'intérieur des parties sud et sud-ouest du camp minier de Bathurst-Newcastle. Ces travaux visent à compléter les études structurales en cours entreprises par le personnel de la Commission géologique du Canada et de la Direction des études géologiques du Nouveau-Brunswick. Les travaux sur le terrain ont jusqu'à maintenant donné lieu à l'examen d'environ 4 000 affleurements et au prélèvement de plus de 2 400 échantillons de roches des régions étudiées en 1990 et 1991. Des analyses géochimiques de roches entières et des études pétrographiques approfondies de ce stock énorme d'échantillons seront entreprises en vue de mieux définir les unités stratigraphiques et les faciès volcaniques.

La région d'étude de Halfmile Lakes - Heath Steele repose sur plusieurs formations rocheuses comprenant le groupe de Tetagouche de l'Ordovicien moyen. Quoique, en général, on rencontre un certain chevauchement dans le temps entre des unités successives, ces formations sont, de la plus vieille à la plus jeune, les formations du ruisseau Patrick, des chutes Nepisiguit, du ruisseau Flat Landing, du lac Canoe Landing et du ruisseau Boucher (van Staal et Fyffe 1991). Les arénites quartzeuses et les wackestones représentant probablement la sous-couche du groupe de Miramichi sont exposés dans la partie sud-ouest de région étudiée près du mont Little Bald. Des roches intrusives siluriennes servent de sous-couche à des portions de l'angle sud-ouest de la région étudiée, et elles comprennent le granit à biotite de Miramichi, et le gabbro du lac Goodwin, qui abrite un petit gisement de cuivre-nickel à proximité du mont Maliseet.

Les roches appartenant à la formation du ruisseau Patrick ne sont pas courantes dans la région étudiée et elles ne se manifestent que dans l'angle sud-ouest du mont Little Bald. La formation du ruisseau Patrick comprend du grès lithologique et du grauwacke (probablement des sédiments épiclastiques) et des métapélites recouvrant les roches quartzeuses du groupe de Miramichi. La formation des chutes Nepisiguit est composée d'écoulements de quartz-feldspath-rhyolite phyrique et de dômes et de sills intrusifs (porphyre quartzeux-feldspathique), ainsi que de roches équivalentes communément appelées schistes oeillés de quartz-feldspath se trouvant dans les zones soumises à de fortes contraintes. Des roches épiclastiques quartzeuses ou feldspathiques, proximales à distales, sont en général associées à ces porphyres. Aucune évidence texturelle n'a été décelée pour appuyer la thèse de certains chercheurs antérieurs, selon laquelle au moins certains porphyres quartzeux-feldspathiques ont une origine pyroclastique. Par exemple, aucune pierre ponce n'est observée, et les phénocristaux sont normalement intacts, sauf lorsqu'ils ont subi des tractions tectoniques; les cristaux de quartz sont souvent profondément ennoyés et intacts. On ne décèle pas d'éclats de paroi soufflée et, bien qu'ils aient pu s'oblitérer par déformation ou métamorphisme, la préservation fréquente des textures primaires, telles les

textures sphérolitiques et sperlitiques, laisse supposer que les éclats, le cas échéant, devraient également être préservés localement.

La formation du ruisseau Flat Landing est principalement composée de rhyolites subaquatiques aphyriques ou feldspathiques-phyriques présentant souvent des textures perlitiques ou sphérolitiques, révélatrices 1d'un état vitreux antérieur. Des brèches et des microbrèches felsiques palagonitiques, ainsi que des roches épiclastiques associées (tufs vitreux), sont considérées comme des roches autoclastiques formées par le trempage-éclatement et par le délitage des bords des écoulements et des dômes rhyolitiques vitreux subaquatiques. Ces roches contiennent, en général, des fragments felsiques angulaires roses dans une matrice chloritique granulaire verte, interprétée comme du verre rhyolitique granulé modifié. Ces roches ont été précédemment interprétées comme des tufs et des agglomérats mafiques; toutefois, leur association spatiale étroite à des rhyolites massives sphérolitiques ou perlitiques, l'abondance en profondeur de clastes rhyolitiques angulaires, et leur similitude en section mince aux hyaloclastites felsiques notées dans les paragénèses volcaniques du Dévonien inférieur, dans la région de Tobique, laisse supposer qu'un grand nombre de ces «clastes chloritiques» ont été étiquetées de façon erronée. La formation du ruisseau Flat Landing comprend également des roches sédimentaires épiclastiques locales secondaires, ainsi que des basaltes et des gabbros tholéiitiques (van Staal et Fyffe 1991).

La formation du lac Canoe Landing ne se manifeste que dans une petite partie de l'angle nord-est de la région étudiée, et elle est composée de basalte alkalin en coussins. La formation du ruisseau Boucher, lithologiquement variable dans la région étudiée, est principalement constituée de diverses roches sédimentaires, notamment de métagrauwacke ou de waucke lithologique, de métasiltite, d'ardoise, de métapélite (roches et limons compacts manganésifères et localement graphiteux de couleur gris foncé à noire) ainsi que d'ardoise, de siltite et de silexite (appelée unité RMS) hématitiques et manganésifères de couleur gris foncé à brun rougeâtre. Le basalte, souvent intercalé dans les roches sédimentaires (basalte alkalin Brunswick - van Staal et Fyffe 1991), se présente également sous forme d'une unité épaisse sans roches sédimentaires, au sud-est de la mine Heath Steele.

REFERENCE

VAN STAAL, C.R., and FYFFE, L.R. 1991. Dunnage and Gander zones, New Brunswick: Canadian Appalachian Region. New Brunswick Department of Natural Resources and Energy, Mineral Resources Division, Geoscience Report 91-2, 39 p.

NOTES

GEOLOGICAL SURVEYS BRANCH

MINERAL DEPOSITS AND GIS SECTION

ACTIVITIES OF THE MINERAL DEPOSITS AND GIS SECTION[a]

R.R. Irrinki
Senior Geologist

The Mineral Deposits and GIS (Geographic Information System) section staff consists of Rao Irrinki (Senior Geologist), Bill Gardiner (Mineral Deposits Geologist), Greg Crouse (Drill-core Manager and MESP Coordinator), Paul Rennick (Project Geologist, C-NBCAMD), and Laurie McNeill (GIS Operator, C-NBCAMD).

Rao Irrinki and Paul Rennick continued the computerization of drill-hole data on major metallic mineral deposits. The available drill-hole information on the Sewell Brook and Nash Creek deposits has been entered into the computer. Several sections have been generated for the Sewell Brook deposit.

Rao Irrinki, Laurie McNeill, Paul Rennick, and Terry Leonard (Policy, Planning, and Administration Branch) are involved in carrying out the Geoscience Information System (GSIS) projects. These projects are:

1. Base-map maintenance
2. Geoscience-data compilation
3. Geological data maintenance
4. Geophysical data maintenance
5. Geochemistry-data maintenance
6. Mineral-occurrence-data maintenance
7. Mineral-deposits-data maintenance

In coordination with Jacques Thibault (Mineral Development Branch), two pilot projects involving Coastal Zone mapping and Peatland Management are in progress. In cooperation with Fred Edney (Mineral Development Branch), a pilot project on claim-tracking system using GSIS is also in progress.

Rao Irrinki presented the following two talks: in March, a talk entitled "Geological Surveys Geoscience Information System Activities" was given at the Land Information Forum 91 held in Fredericton; in May, a talk on "Current GSIS Projects" was given to the New Brunswick Geomatics Association held at Keddy's Inn, Fredericton. In September, Rao Irrinki attended a conference entitled "Computer Applications in the Mineral Industry" held in Vancouver, B.C.

The GIS section organized two workshops on "GIS and Digital Image Analysis in Geology". Rao Irrinki represented the Mineral Resources Division on the Standards Committee, Mapping Subcommittee, and three working groups (Terminology, Future Entity Classification, and Spatial Referencing) related to geographic information.

Bill Gardiner continued to work on mineral occurrences related to the Antinouri-Nicholas project. To date, a total of two hundred and forty-three occurrences have been identified, with one hundred and seventy-seven being field checked during the 1990-91 field season. He also provided informal consultation to prospectors and mineral exploration companies and conducted two prospecting courses in Fredericton and Bathurst.

Bill Gardiner, as Coordinator of the Mineral Occurrence File, is also responsible for updating the file. Sixty-eight new occurrences were identified (exclusive of Antinouri-Nicholas Project) by reviewing old and new assessment files and will be incorporated with the Mineral Occurrence File. The updated file will be released to the public every year.

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[a]The work of the Mineral Deposits and GIS Section is primarily aimed at building a mineral-deposit database necessary for the formulation of mineral exploration models, and to calculate the reserves contained in the more promising deposits.

Greg Crouse coordinated the Mineral Exploration Stimulation Program (MESP) and updated the drill-core and sample databases. Thirty-nine applicants received MESP grants for 1991-92. To date, $65 000 has been given as MESP grants, and $10 000 was spent to conduct prospecting courses. The progress of this program over the last three years is being reviewed.

Paul Rennick continued work on the Antinouri-Nicholas geoscience data compilation project. The data have been compiled for map sheets 21 O/16a, P/12e, and P/13d. Work on 21 P/12f, g and P/12b, c is in progress. He represented the Mineral Resources Division on the GIS Subcommittee of the New Brunswick Mapping Committee.

ACTIVITÉS DE LA SECTION DES GÎTES MINÉRAUX ET DU SIG

R. R. Irrinki
Géologue principal

Le personnel de la section des gîtes minéraux et du SIG (Système d'information géographique) est composé de Rao Irrinki (géologue principal), Bill Gardiner (géologue — gîtes minéraux), Greg Crouse (responsable des carottes de forage et coordonnateur du PSEM), Paul Rennick (géologue d'études, EEM) et Laurie McNeill (opératrice du SIG, EEM).

Rao Irrinki et Paul Rennick ont poursuivi l'informatisation des données des carottes de forage sur les principaux gîtes minéraux métalliques. L'information dont ils disposent grâce aux carottes de forage des gisements du ruisseau Sewell a été introduite dans l'ordinateur. Plusieurs sections ont été produites pour le gisement du ruisseau Sewell.

Rao Irrinki, Laurie McNeill, Paul Rennick et Terry Leonard (Direction des politiques, de la planification et de l'administration) participent à l'exécution des projets du Système d'information géoscientifique (SIGS). Ces projets sont les suivants :

1. la mise à jour des cartes de base;
2. la compilation des données géoscientifiques;
3. la mise à jour des données géologiques;
4. la mise à jour des données géophysiques;
5. la mise à jour des données géochimiques;
6. la mise à jour des données sur les venues minérales;
7. la mise à jour des données sur les gîtes minéraux.

Conjointement avec Jacques Thibault (Direction de l'exploitation des ressources minières), deux projets-pilotes comportant des travaux cartographiques des zones côtières et l'aménagement de tourbières sont en cours. Un projet-pilote sur le système de localisation des claims utilisant le SIGS est également en cours avec la collaboration de Fred Edney (Direction de l'exploitation des ressources minières).

Rao Irrinki a présenté les deux exposés suivants : en mars, un exposé intitulé «Activités sur le système d'information géoscientifique relativement aux études géologiques» a été donné au Land Information Forum 1991 qui s'est tenu à Fredericton; en mai, un exposé sur les «Projets SIGS en cours» a été présenté à la New Brunswick Geomatics Association, à l'hôtel Keddy's, à Fredericton. En septembre, Rao Irrinki a assisté à une conférence intitulée «Computer Applications in the Mineral Industry», qui a eu lieu à Vancouver, en Colombie-Britannique.

La section du SIG a organisé deux ateliers sur le SIG et l'analyse de l'image numérique en géologie. Rao Irrinki a représenté la Direction de l'exploitation des ressources minières au comité des normes, au sous-comité de la cartographie et au sein de trois groupes de travail (terminologie, classification des entités futures et repérage spatial) reliés à l'information géographique.

Bill Gardiner a continué à travailler sur les venues minérales reliées au projet Antinouri-Nicholas. Jusqu'à présent, un total de 243 venues ont été identifiées, parmi lesquelles 177 ont été vérifiées au cours des saisons d'étude sur le terrain de 1990-1991. Il a également offert une consultation informelle aux prospecteurs et aux sociétés d'exploration minière, et il a donné deux cours de prospection à Fredericton et à Bathurst.

Bill Gardiner, coordonnateur du dossier des venues minérales, est également responsable de la mise à jour du dossier. Soixante-huit nouvelles venues ont été identifiées (projet Antinouri-Nicholas non compris) en examinant les anciens et nouveaux dossiers d'évaluation. Elles seront intégrées au dossier des venues minérales. Le dossier mis à jour sera publié chaque année à l'intention du public.

Greg Crouse a coordonné le Programme de stimulation de l'exploration minière (PSEM) et a mis à jour les bases de données des carottes de forage et des échantillons. Trente-neuf candidats ont reçu des subventions du PSEM pour 1990-1991. Jusqu'à maintenant, 65 000 $ ont été octroyés en subventions du PSEM, et 10 000 $ ont été investis dans des cours de prospection. On est en train d'évaluer les progrès réalisés grâce à ce programme au cours des trois dernières années.

Paul Rennick a poursuivi son travail dans le cadre du projet de compilation des données géoscientifiques d'Antinouri-Nicholas. Les données des feuilles topographiques 21 O/16a, P/12e et P/13d ont été compilées. Les travaux relatifs aux feuilles topographiques 21 P/12f, g et P/12b, c sont en cours. Rennick a représenté la Division des ressources minérales au sous-comité du SIG du comité de cartographie du Nouveau-Brunswick.

PROJECTS OF THE GEOSCIENCE INFORMATION SYSTEM (GSIS)*

R.R. Irrinki
Senior Geologist

The Geoscience Information System was established to manage information collected by the Mineral Resources Division. The system is mainly intended for internal use in order to efficiently carry out the objectives of the Mineral Resources Division. The hardware configuration of the system consists of one Sparc 370 Server, one Sun4 workstation and associated peripheries. UNIX is the operating system, CARIS (Computer-Aided Resource Information System) is the graphic software, and INGRES is the software for relational database management. After the successful completion of the pilot project, the following projects are in progress: (1) base map maintenance for most parts of New Brunswick; (2) geoscience data compilation for 21 O/8, Antinouri-Nicholas project area, and 21 P/5 map sheet; (3) geological data maintenance for 21 G/6h, G/7e, O/9h, O/16a, P/13d, G/14a, b, g, h, G/15a, d, G/11g, h, and O/8; (4) geophysical data maintenance for 21 O/8, Antinouri-Nicholas project area, Lake George project area; (5) geochemistry deta maintenance for 21 O/8, parts of 21 G/14; (6) mineral occurrence - 21 P/12e, f, P/13c, d; (7) mineral deposits - Murray Brook, CNE, Sewell Brook, and Nash Creek; (8) claim tracking system - pilot project; (9) coastal zone mapping - pilot project; and (10) peatland management - pilot project

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Le Système d'information géoscientifique a été établi en vue de gérer l'information recueillie par la Division des ressources minérales. Le système, destiné essentiellement à un usage interne, doit permettre de réaliser efficacement les objectifs de la Division des ressources minérales. La configuration matérielle du système comprend un serveur Sparc 370, un poste de travail Sun4 et les périphériques associés. UNIX est le système d'exploitation; CARIS (Computer-Aided Resource Information System), le logiciel graphique; et INGRES, le logiciel de gestion des bases de données relationnelles. Lorsque le projet-pilote aura été mené à terme avec succès, les projets suivants seront en cours : 1) la mise à jour des cartes de base pour la plupart des parties du Nouveau-Brunswick; 2) la compilation des données géoscientifiques de feuille topographique 21 O/8, région d'étude d'Antinouri-Nicholas et de la feuille topographique 21 P/5; 3) la mise à jour des données géologiques des feuilles topographiques 21 G/6h, G/7e, O/9h, O/16a, P/13d, G/14a, b, g, h, G/15a, d, G/11g, h et O/8; 4) la mise à jour des données géophysiques de la feuille topographique 21 O/8, région d'étude d'Antinouri-Nicholas, région d'étude du lac George; 5) la mise à jour des données géochimiques de la feuille topographique 21 O/8, des parties de la feuille topographique 21 G/14; 6) les venues minérales — 21 P/12e, f, P/13c,d; 7) les gîtes minéraux — ruisseau Murray, CNE, ruisseau Sewell et Nash Creek; 8) le système de localisation des claims — projet-pilote; 9) les travaux cartographiques des zones côtières - projet-pilote; 10) l'aménagement des tourbières - projet-pilote.

BACKGROUND

The Geoscience Information System was established to manage information collected by the Mineral Resources Division. Funding provided from the C-NBCAMD and the Innovation and Technology subagreement was used to purchase GIS hardware and to customize GIS-CARIS (Computer Aided Resource Information System) for geoscience applications.

The hardware configuration of the system consists of one SPARC 370 SERVER with 32 megabytes of memory and 1.5 gigabytes of hard-disk storage, one SUN 4 workstation with 16 megabytes of memory and 700 megabytes of hard-disk storage, two 19" colour monitors, one E-size pen plotter, one E-size digitizer, one USL controller, and one Tektronics screen dump. UNIX is the operating system for the hardware; CARIS is the GIS software and is used to manage the graphic database; and INGRES is the relational database management system. The hardware and software meet all of New Brunswick's information standards. Three projects are being carried out: (1) geoscience information system databases; (2) workshop on GIS and digital image analysis in geology; and (3) geoscience field data collector.

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*The Geoscience Information System was established through funding derived from the Canada - New Brunswick Mineral Development Agreement (1984-89), and an Industrial Innovation and Technology subagreement. The total funding ($400 000) was used to purchase GIS hardware and to customize GIS-CARIS (Computer Aided Resource Information System) for geoscience applications.

GEOSCIENCE INFORMATION SYSTEM DATABASES

The Geoscience Information System has three objectives: digital base-map maintenance, geoscience data compilation, and geoscience data integration. The system is mainly intended for internal use in order to efficiently attain the objectives of the Mineral Resources Division. It is hoped that the system will eventually not only help to attract more exploration dollars to the Province, but also to promote environmentally sustainable development in the mineral resources sector.

Base Map Maintenance:

Mineral Resources staff and the mineral industry (prospectors, exploration companies, and mining companies) are extensive users of base maps, ranging in scale from 1:10 000 to 1:500 000 (Table 1). At present, both staff and industry use mainly hard-copy maps derived from various sources. These are NBDNRE 1" = 20 chains and 1" = 40 chains, Federal 1:50 000 and 1:250 000, New Brunswick Geographic Information (NBGIC) 1:10 000 and 1:20 000 orthophotos, NBGIC 1:10 000 line maps, Timber Management Branch (TMB) 1:12 500, and MAPLINC (Amherst, formerly MRMS) 1:10 000 line maps. Several other maps of various scales are created by photographically manipulating the above set of maps. To date, the Mineral Resources Division and industry have spent large sums of money to obtain nonstandardized, inaccurate maps derived from various projections and standards.

The Province of New Brunswick recognized the need to standardize base maps and established LRIS (Land Registration and Information Service) 1:10 000 maps as a Provincial standard base upon which all geographic information will be built. In order to strengthen this concept, the Province has further established the N Brunswick Geographic Information Corporation (GIC), which has the mandate to create, maintain, and distrib base maps. At present, these maps are only in digital form and one needs a GIS (Geographic Information System) to use these standardized base maps.

The Mineral Resources Geoscience Information System (GSIS) has been used to customize LRIS 1:10 000 digital base maps and then to create Resource 1, Resource 2, and Resource 3 types of hard-copy base maps. At present, 600 out of 1885 maps are on the system. All these maps are from southern New Brunswick, but it is hoped that all the LRIS 1:10 000 digital files will be on the system by September 1993 – the expected date of completion by LRIS. The GSIS has been used to create customized base maps for all staff needs.

LRIS and GIC charge $150 for each 1:10 000 digital file. According to this pricing policy, it would cost $282 750 (1885 X $150) to obtain all the 1:10 000 digital files. Because of the Geological Surveys Branch agreement with GIC and LRIS (Summerside, PEI), the Branch is acquiring these digital files at no cost. In return, the Geological Surveys Branch is providing merged files created by GSIS to LRIS Summerside.

Merging of LRIS 1:10 000 files involves five steps. The first step is to write a program to network the 1:10 000 files. The second step is to standardize the file transfer routines and media. Next, the files are processed by using the above networking program that automatically corrects the majority of topological errors. The fourth and fifth steps involve manual editing of the files coming out of the networking program; the files are then merged to the required scale (1:50 000).

By September 1993, all LRIS 1:10 000 (1885) for New Brunswick should be cleaned and merged to 1:50 000 and 1:250 000 scales. These maps have been recommended for use in the maintenance of all resource information. Federal 1:50 000 and 1:250 000 maps will become obsolete.

Geoscience Data Compilation:

One of the priorities of the Mineral Resources Division is to compile all geoscientific information contained within assessment reports submitted to the Mining Recorder. These reports document the work done by mining companies and prospectors to maintain their mineral properties in good standing. Because of the great amount of data, manual treatment of this information is becoming more and more cumbersome, inefficient, and expensive. In order to use the information more effectively, the Geological Surveys Branch started compiling these data, beginning with the California Lake map sheet (NTS 21 O/8) as a pilot project. This work was contracted out at a cost of $80 000. The data were published as one hundred and twenty-five 1:10 000 maps that

TABLE 1. BASE MAP USER SURVEY RESULTS
MINERAL RESOURCES DIVISION

NAME	AFFILIATION	BASE MAP NEEDS		REQUIRED THEMES (FEATURES)	MAINTENANCE SUGGESTIONS
		HARD COPY	DIGITAL		
Sean Jackson	Brunswick Mining & Smelting	-	1:10 000 SIF Format	Resource - 1	Update on yearly basis Forest access roads
David Keys	Maritime Groundwater	1:10 000; 1:20 000; 1:50 000	In near future	Resource - 3	Needs updates
Bob Stewart	Falconbridge	1:50; 1:10 000; 1:250 000	1:10 000; 1:250 000	Resource - 1	Update on yearly basis input from each department (Forestry & Transportation)
John Langton	M.R. Staff	1:10 000	1:10 000	Resource - 1	Updated by Forestry & Transportation
Steve McCutcheon	M.R. Staff	1:10 000; 1:20 000; 1:50 000	1:10 000; 1:20 000; 1:50 000	Resource - 1	Updates as needed; Forestry & Transportation
Michael Parkhill	M.R. Staff	1:10 000; 1:50 000	1:10 000; 1:50 000	Resource - 1	Updated yearly from Forestry & Transportation
Bob Butler	M.R. Staff	1:10 000	1:10 000	Resource - 3	-
Jacques Thibault	M.R. Staff	1:10 000; 1:50 000; 1:250 000	1:10 000; 1:250 000	Resource - 3	-
Clint St. Peter	Energy Staff	1:1 000; 1:10 000; 1:20 000 1:50 000; 1:250 000	1:10 000; 1:250 000	Resource - 2	-
Les Fyffe	M.R. Staff	1:10 000	1:10 000	Resource - 1	-
Ron Shaw	Energy Staff	1:10 000	-	Resource - 3	1:4 800 updates from mining companies
Fred Edney	M.R. Staff	1:50 000; 1:250 000	1:50 000	Resource - 2	-
Gerry Johnson	M.R. Staff	1:10 000; 1:20 000 1:50 000; 1:250 000	1:10 000; 1:250 000	Resource - 1, 2, 3	Updated yearly from Forestry road network
Allen Seaman	M.R. Staff	1:50 000	-		Needs up-to-date road network
Bill Gardiner	M.R. Staff	1:10 000; 1:20 000;	1:10 000	Resource - 1, 3	Yearly by using Forestry and Transportation updates
Brian Rousseau	Pennah Company of Ashevia		1:10 000; 1:50 000	Resource - 1, 3	Once in 5 years
Al Bunn	Elmtree Resources	1:10 000; 1:20 000		Resource - 1	2-4 year logging roads
Malcolm McLeod	M.R. Staff	1:10 000; 1:50 000; 1:250 000	In near future	Resource - 1	Updated each year
Ken Whaley	Ken Whaley Ltd.	1:10 000; 1:50 000	-	Resource - 1	Needs updates
S. Weidner	Rio Algom Exploration	1:10 000; 1:50 000 1:250 000	-	Resource - 1	Yearly Updates logging roads
Peter Dufour	N.B. Coal	1:5 000; 1:10 000 1:50 000	-	Resource - 3	Yearly Updates by using property maps
Robin Adair	Noranda Exploration	1:10 000	1:10 000 (DXF)	Resource - 1	-
Don Burton	NovaGold Resources	1:10 000; 1:20 000 1:50 000; 1:250 000	1:10 000	Resource - 1	5-10 year updates; aerial photographs & satellite
Paul Rennick	M.R. Staff	1:10 000; 1:20 000 1:50 000	1:10 000; 1:250 000	Resource - 1	Yearly updates - road network

The survey was carried out by R.R. Irrinki in order to obtain base map requirements of Mineral Resources staff and industry.

Resource 1: This map series contains hydrography, four classifications of roads, contours at 10 m intervals and a few place names. The common scales are 1:10 000 and 1:20 000. All geology maps use this base.

Resource 2: This map series contains limited hydrography, 2-3 classifications of roads, and a few place names. The common scales are 1:50 000 and 1:250 000. All mineral claim maps use this base.

Resource 3: This map series contains most of the LRIS features except contours. The common scales are 1:10 000 and 1:20 000. This base is commonly used for Peat management, mining plans, reclamation plans, and groundwater assessment.

include base, geology, geophysics, geochemistry, and annotation layers. Work-location maps at 1:50 000 scale were published as four maps consisting of the work done between 1950-59, 1960-69, 1970-79, and 1980 to present.

The project was then extended to cover NTS 21 P/5, costing an additional $80 000. The geocompilation project began in response to mineral industry demands and the fact that these kind of data are readily available in other provinces and territories. The industry would like this coverage extended to most parts of New Brunswick (90 NTS sheets).

The geocompilation project was incorporated into the pilot project when the system became available. All the hard-copy maps (120+) for 21 O/8 were digitized by using the GSIS. The project was then extended to cover the Antinouri-Nicholas area (parts of 21 O/9, 16, and 21 P/12, 13) and 21 P/5 map area. It has been documented that the geocompilation would cost $60 000/NTS sheet by using the GSIS in contrast to $200 000 ($110 000 for base maps + $90 000 for contract work) using traditional methods. Furthermore, the Geoscience Information System produces far superior databases.

In summary, the GSIS can produce better quality geocompilation databases at a lower cost.

Geoscience Data Integration:

Geoscientists and engineers need access to all available geoscience databases to efficiently carry out their duties in the management of New Brunswick mineral resources. Geoscience databases comprise geology, geophysics, geochemistry, mineral occurrences, mineral deposits, mining and reclamation plans, claims, sand and gravel pits, coastal zone, and peat.

Geological Data Maintenance:

The Geological Surveys Branch staff have been involved in the collection of geoscience data for many years. The Branch manages a geoscientific database acquired over 50 years by itself, the Federal Government, academic institutions, exploration companies, and prospectors. These data are commonly published in hard-copy format. Only about 50% of the recorded data are actually presented in these publications; the other 50% are mostly in the form of field notes.

The Geological Surveys Branch publishes geological maps at 1:15 840, 1:31 680, 1:50 000, and 1:250 000 scales. In order to comply with Branch policies, the data have to be transferred to 1:20 000 scale for integration purposes. Manual conversion of geoscience data to 1:20 000 scale is not only expensive, but time-consuming. Conversion of hard-copy maps to digitized maps will take 8 to 12 hours per map. The geoscience data currently collected have been maintained on the system.

To date, the following geology maps have been digitized: 21 O/8; G/16h; G/7e; O/9h; O/16a; P/13d; G/14a, b, g, h; G/15a, d; and G/11g, h.

Geophysical Data Maintenance:

Geophysical data are gathered mainly by the Geological Survey of Canada and published mostly as 1:50 000-scale maps. These data consist of airborne magnetics, airborne radiometrics, and airborne EM. Gravity data are available at wide intervals. Ground geophysical data are also available for various parts of New Brunswick. These data have been collected at a cost of several tens of millions of dollars and are essential in the interpretation of geology and exploration for new mineral deposits.

To date, the following geophysical and remote sensing data have been acquired:

1. Ten layers of geophysical data (7 layers of radiometrics, total field magnetics, VLF-quadrature and VLF-total electric field), and seven bands of LANDSAT5 for 21 O/8, Antinouri-Nicholas project area, and Lake George project area
2. Gravity data for 21 O/8
3. Profile data for 10 layers of geophysics for map sheet 21 O/8. The profile data have been contoured at various intervals and integrated with the other thematic layers.

The index for all available airborne geophysical data (Mag, EM, and Radiometrics) is being compiled for the Province of New Brunswick and will be available in the near future. During the next two years, all the available geophysical data from the Geological Survey of Canada will be integrated with the system.

In summary, the system is valuable for maintaining geophysical data, collected by government and industry at the expense of several tens of millions of dollars.

Geochemistry Data Maintenance:

The Geological Surveys Branch and Geological Survey of Canada collect samples of stream sediments, water, soil, till, and rock as part of geochemical exploration. The samples are then analysed for 20 to 30 elements such as copper, lead, zinc, and mercury. These data are published on geochemical map plates. This geochemical database is essential for monitoring the environment, forest-site classification, groundwater management, and fish and wildlife habitat.

During the pilot project, the geochemical data for 21 O/8 were integrated with the other data sets. The pilot project documented the database structure in dBase and INGRES. The database is now retrievable both texturally and graphically according to the user-defined criteria. The Branch also plans to integrate all the available geochemical data for New Brunswick and has applied for an "Environmental Trust Fund" grant to help finance this project. In summary, a geochemical database can be better maintained by using the GSIS. The data would then be available to a number of departments for various applications.

Mineral Occurrence Data Maintenance:

The data on 800+ mineral occurrences have been maintained by the New Brunswick Computerized Mineral Occurrence Database, which is managed by four dBase files: Deposits.dbf; Rock.dbf; TPA.dbf; and Ref.dbf. They describe the mineral-deposit characteristics, rocks associated with the deposits, tonnage, and references, respectively. All these data have been converted to CARIS format. The mineral occurrence data collected for the Antinouri-Nicholas project are being integrated with the system.

Mineral-Deposit-Data Maintenance:

Drill-hole data on several major deposits, including tonnage data, are presently managed by four dBase files that include information on location, deviation, assays, and geology. A special software package by Geostat Systems International Incorporated has been used to produce cross- and longitudinal-sections, plans, histograms, and to estimate reserves from the drill-hole data. This special software creates CARIS compatible graphic files. At present, mineral-deposit data on ten major metallic mineral deposits were integrated into the system. There are at least 40 such deposits in the Province. All these data can be integrated into the system depending upon the available resources.

Mining Plans and Reclamation Data Storage:

The Mineral Development Branch receives and stores mining and reclamation plans for all developing mines. Most of these data are in hard-copy format and should be digitized for effective management.

Claim-Tracking System (Pilot Project):

The Mineral Development Branch records mineral claims staked in the Province by using a claim-tracking system that is managed by dBase programs. These claims are manually plotted on 1:50 000 and 1:250 000 scale maps and are frequently updated. The purpose of this system is to track mineral claims staked by prospectors within New Brunswick. The program is written in dBase III Plus and is currently designed to be used in a single-user, IBM PC, or compatible environment. The system is mainly managed by tag.dbf, group.dbf, and licence.dbf.

The present system is not capable of handling graphic files. The claims are presently plotted manually at 1:50 000 and 1:250 000 scales in Fredericton, Bathurst, and Sussex offices, so there is duplication in recording of claims. The conversion of all claims to digital format is under review.

Sand and Gravel Pit Management:

The data on sand and gravel pits are managed by a database file using the WANG system. At present, the location of each pit is manually plotted on 1" = 40 chain maps. It would take only two to three weeks to digitize all the available data on gravel pits for integration with the GSIS.

Coastal Zone Mapping (Pilot Project):

The Mineral Development Branch has been collecting data along the coast stretching from Moncton to Campbellton. The data should be integrated with the GSIS for effective management of coastal resources.

Peatland Management (Pilot Project):

The data for 1000 peat bogs in the Province are being managed by several dBase files. Several of the developing bogs also have a tremendous amount of data containing base and therapeutic information. Both the textural data (dBase files) and graphic data have to be integrated for effective management. We are presently working on a pilot program.

Geoscience Data Integration (Summary)

The above digital data sets consisting of base maps, compilation data, geology, geophysics, geochemistry, remote sensing, mineral occurrences, mineral deposits, mining, reclamation, sand and gravel, and mineral claims were integrated into the Geoscience Information System. It is now possible to retrieve the data in various combinations. The required layers would then be plotted with the pen plotter or by using the Tektronics screen dump.

Spatial Analysis and Modelling

Spatial analyses involve combining data from multiple spatial data sets and performing spatial analysis techniques and modelling to transform GIS data sets into information suitable for a given purpose. For example, if an exploration company is looking for exploration targets, the data sets should contain geology, geophysics, geochemistry, mineral occurrences, and assessment data layers. Each data set will be weighted in comparison to the others, with the resulting data providing the target areas. The GIS would not be used immediately for spatial analysis and modelling due to limitations on the availability of data sets. The analysis would be limited to project areas.

WORKSHOP ON GIS AND DIGITAL IMAGE ANALYSIS IN GEOLOGY

The Mineral Resources Division of the New Brunswick Department of Natural Resources and Energy organized workshops on February 22-24, 1991 and March 14-16, 1991 to enable mining companies and Mineral Resources staff to become more familiar with the processing, analysis, and use of digital image and map data, and with the integration of data originating from various sources.

Representatives from Noranda Exploration, K.D.A. Whaley Consultants, the Prospectors & Developers Association, Three-D Geoconsultants, Maritime Groundwater, GEOSLEUTHS, and the Mineral Resources staff attended the workshops. Eugene Derenyi (U.N.B., Dept. of Surveying Engineering), Tim Perrott (CCRS), Mike Lodin (Geodat), Paul Williams, Bryan MacEachen, and Steve Ralser (U.N.B., Geology Dept.), along with Rao Irrinki, Paul Rennick, and Laurie McNeill (Mineral Resources Division; NBDNRE) provided the theoretical background and practical training on digital geoscience data sets presently maintained by Mineral Resources.

The workshops were well received and appreciated by both industry personnel and Mineral Resources staff. The workshops provided an atmosphere of close cooperation among geoscientists of Industry, University, and Government for the development of the Geoscience Information System (GSIS), digital data sharing, and digital data creation.

GEOSCIENCE FIELD DATA COLLECTOR (GEO-100)

The hand-held computer was built by Advanced Systems Design Ltd. according to the specifications given by the Geological Surveys Branch and will be used for recording field data. The Field Data Collector provides an economical means of collecting information needed for geoscience field surveys. It partly automates the data

collection procedure by eliminating pencil and paper and replacing them by an electronic data entry terminal. In addition, a built-in microprocessor aids the operator in the collection procedure by guiding him/her through the entries of the data sets, avoiding omission of important information and reducing operator errors. The data sets are automatically date/time-stamped.

The Data Collector Terminal is small in size, hand-held, and powered by rechargeable batteries for several continuous full-shift operations (up to 30 hours). The data memory and the clock/calendar are backed up by battery power so that information is retained even when the terminal is turned off. The terminal is designed for use in adverse climatic conditions over a wide temperature range and does not have any external cables or connectors which could corrode and cause unreliable operation. The terminal can be placed in its Interface Cradle where recharging takes place and where the transfer of field data to a host computer is performed. Separate date/time-stamped data sets can be constructed for up to 45 field sites. The data sets can be transferred into a host computer for subsequent processing by suitable software packages, such as spreadsheet programs, database programs or GIS systems.

The specifications, list of fields and attributes, and hierarchy of data groups and fields are given in Tables 2, 3, and 4, respectively.

TABLE 2. SPECIFICATIONS

Physical Dimensions:

Data Terminal:	7.5" X 4" X 0.8" (l X w X h); 500 g; moisture-resistant enclosure
Interface Cradle:	8.5" X 6.5" X 3.5" (l X w X h); 1.1 kg without AC adapter

Electrical Specifications:

Data Terminal	Self-contained with its own power supply (rechargeable NiCd batteries)
Interface Cradle:	External AC adapter 115VAC, 8W or car adapter 12V, 500mA

Environmental Specifications:

Data Terminal:	Operating range -25 to +40°C, non-condensating. All terminals are tested at -25°C for a period of 12 hours before shipment. At temperatures below the freezing point, the information of the CLD display changes slowly: this is a characteristic of all LCD displays and does not effect the overall operation of the terminal.
Interface Cradle:	Operating range 0 to 40°C, non-condensating.

Operating Period:

Data Terminal:	Approximately 30 hours on full charge at 25°C, 15 hours at -25°C. Memory backup approximately 10 days at 25°C with terminal turned off.
Charging Time:	Main battery pack: ½ hour charge for every full hour of operation with terminal turned off, up to a maximum of 15 hours (¾ hour with terminal turned on). Backup battery pack: 3 hours a day with the terminal in operation (*i.e.*, turned on).

Data Set Capacity:

Number of Data Sets:	45
Number of ID Areas:	4

TABLE 3. LIST OF FIELDS AND ATTRIBUTES

GROUP	FIELD	ABBREVIATION	LENGTH	ALPH/NUM
Location	Date/Time	Date	8(19)	n
	Field #	Field#	10	n
	Longitude	Lngitde	8	n
	Latitude	Latitde	8	n
	Aerial Photo	A.Photo	8	n
	Other	Other	8	a
	Outcrop	Outcrop	2	p.p.
Select Type	-	-	1	switch
Lithology	Color W/S	Color W/S	5	a
	Intensity W/S	Intens W	1	p.p.
	Color F/S	Color F/S	5	a
	Intensity F/S	Intens F	1	p.p.
	Magnetism	Magn	1	p.p.
	Reaction	React	1	p.p.
Rock Type	-	-	1	switch
Igneous	Gr size	Grsize	4	p.p.
	Pr structure	I-Prstr	8	a + p.p.
	Pr texture 1	I-Prtex1	6	a + p.p.
	Pr texture 2	I-Prtex	6	a + p.p.
	Tops	I-Tops	1	a
	T direction	I-Tdirect	3	n
	Rock type	I-Rty	10	a
	Notes	I-Nte	10	a
Sedimentary	Pr structure 1	S-Prstru1	6	a
	Pr structure 2	S-Prstru2	6	a
	Pr texture 1	S-Prtx1	4	p.p.
	Pr texture 2	S-Prtx2	4	a + p.p.
	Contact	Contact	8	a + p.p.
	Bed thickness	Bed Thick	8	a + p.p.
	Tops	S-Tops	1	p.p.
	T direction	S-Tdirect	3	a
	Fossiis	Foss	1	p.p.
	Rock type 1	S-Rt1	10	a
	R1 percent	S-R1%	3	a
	Rock type 2	S-Rt2	10	a
	R2 percent	S-R2%	3	a
	Notes	S-Nte	10	a

Table 3 Continued

GROUP	FIELD	ABBREVIATION	LENGTH	ALPH/NUM
Metamorphic	M structure 1	M-Stru1	8	a + p.p.
	M structure 2	M-Stru2	8	a
	M texture 1	M-Tex1	8	a
	Metamorphism	Metam	4	p.p.
	Rel R type	Relrtyp	8	a + p.p.
	M grade	Mgrad	8	a + p.p.
	Rock type	M-Rtyp	8	a
	Notes	M-Nte	10	a
Mineralization	Metals 1	Metals1	8	a + p.p.
	Metals 2	Metals2	8	a
	Nonmetals	Nonmet	8	a
	Alteration	Alteration	1	p.p.
	A type	Atype	10	a
	Host	Host	8	a
	Type	M-Typ	10	a + p.p.
	Notes	M-Nte	8	a
Structure	-	-	1	switch
Planar PL1	S0 strike	P1/S0 S	3	n
	dip	P1/S0 D	2	n
	S1 strike	P1/S1 S	3	n
	dip	P1/S1 D	2	n
	S2 strike	P1/S2 S	3	n
	dip	P1/S2 D	2	n
	S3 strike	P1/S3 S	3	n
	dip	P1/S3 D	2	n
	S4 strike	P1/S4 S	3	n
	dip	P1/S4 D	2	n
	S? strike	P1/S? S	3	n
	dip	P1/S? D	2	n
Planar PL2	J1 strike	P2/J1 S	3	n
	dip	P2/J1 D	2	n
	J2 strike	P2/J2 S	3	n
	dip	P2/J2 D	2	n
	V1 strike	P2/V1 S	3	n
	dip	P2/V1 D	2	n
	V2 strike	P2/V2 S	3	n
	dip	P2/V2 D	2	n

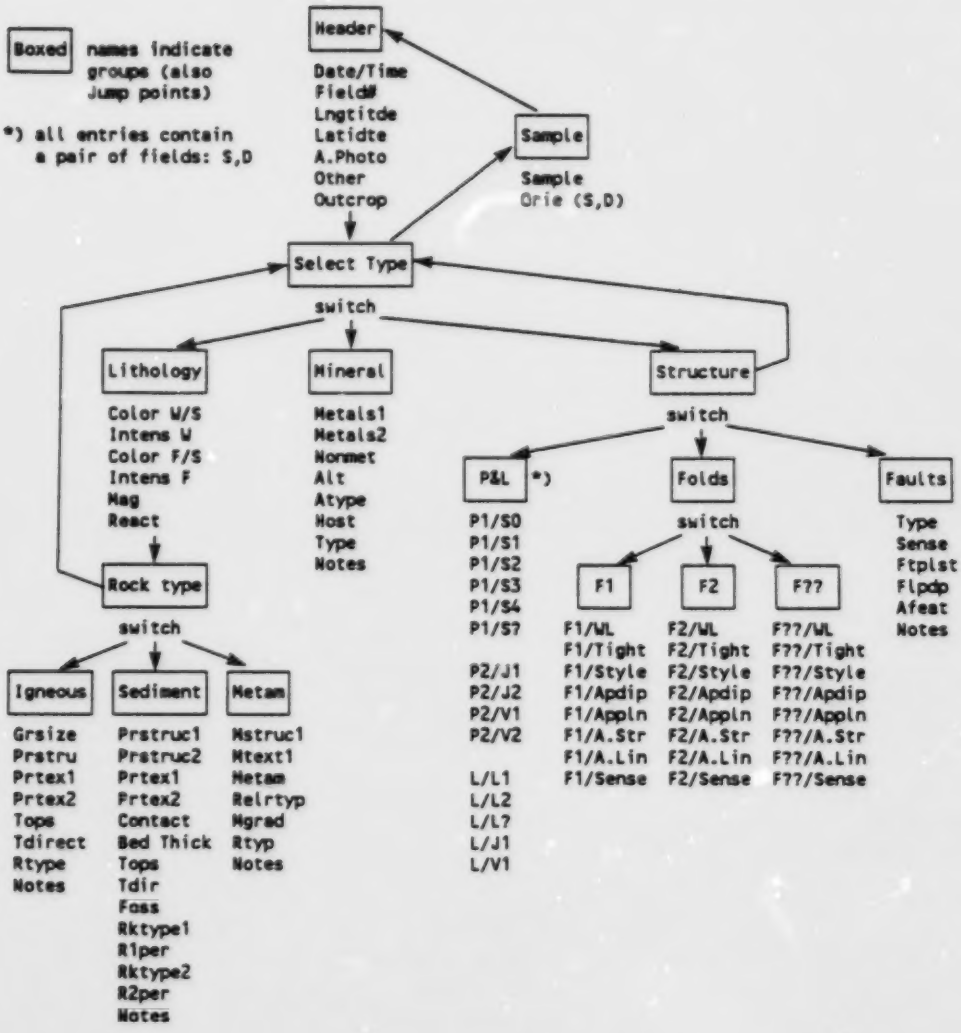
Table 3 Continued

GROUP	FIELD	ABBREVIATION	LENGTH	ALPH/NUM
Linear	L1 strike	L/L1 P	3	n
	dip	L/L1 D	2	n
	L2 strike	L/L2 P	3	n
	dip	L/L2 D	2	n
	L? strike	L/L? P	3	n
	dip	L/L? D	2	n
	LJ1 strike	L/J1 P	3	n
	dip	L/J1 D	2	n
	LV1 strike	L/J2 P	3	n
	dip	L/J2 D	2	n
Folds	-	-	1	switch
	F1 Wave length	F1/WL	3	n
	Tightness	F1/Tignt	4	a + p.p.
	Style	F1/Style	6	a + p.p.
	AP dip	F1/Apdip	4	a + p.p.
	P plunge	F1/Appln	4	a + p.p.
	A str	F1/A.Str	6	a + p.p.
	A lin	F1/A.Lin	4	a + p.p.
	Sense	F1/Sense	1	p.p.
	F2 Wave length	F2/WL	3	n
	Tightness	F2/Tignt	4	a + p.p.
	Style	F2/Style	6	a + p.p.
	AP dip	F2/Apdip	4	a + p.p.
	P plunge	F2/Appln	4	a + p.p.
	A str	F2/A.Str	6	a + p.p.
	A lin	F2/A.Lin	4	a + p.p.
	Sense	F2/Sense	1	p.p.
	F?? Wave length	F??/WL	3	n
	Tightness	F??/Tignt	4	a + p.p.
	Style	F??/Style	4	a + p.p.
	AP dip	F??/Apdip	4	a + p.p.
	P plunge	F??/Appln	4	a + p.p.
	A str	F??/A.Str	4	a + p.p.
	A lin	F??/A.Lin	4	a + p.p.
	Sense	F??/Sense	4	p.p.

Table 3 Continued

GROUP	FIELD	ABBREVIATION	LENGTH	ALPH/NUM
	F?? Wave length	F??/WL	3	n
	Tightness	F??/Tignt	4	a + p.p.
	Style	F??/Style	4	a + p.p.
	AP dip	F??/Apdip	4	a + p.p.
	AP plunge	F??/Appln	4	a + p.p.
	A str	F??/A.Str	4	a + p.p.
	A lin	F??/A.Lin	4	a + p.p.
	Sense	F??/Sense	4	p.p.
Faults	Type	F-Typ	6	a
	Sense	Sense	5	a
	Ftplst	Ftplst	3	a
	Flpldp	Flpdp	2	a
	A feature	Afeat	8	a
	Notes	F-Nte	10	a
Sample	Sample	Sample	3	a
	Orientation	Orie S	3	n
		Orie D	2	n

TABLE 4. HIERARCHY OF DATA GROUPS AND FIELDS



MINERAL OCCURRENCE INVESTIGATIONS AND COMPUTERIZED DATA ENTRY, NEW BRUNSWICK[10]

W.W. Gardiner
Mineral Deposits Geologist

Fifty-seven known mineral occurrences, listed in the New Brunswick mineral occurrence file, are being updated. Sixty-eight new occurrences were identified (exclusive of the Antinouri-Nicholas project) in New Brunswick. Data on these occurrences are being compiled for entry into the N.B. computerized mineral occurrence database. Of these known and new occurrences, fifty-four have been field-checked.

Cinquante-sept gîtes minéraux connus sont présentement mis à jour. On a repéré 68 nouveaux gisements (à l'exception du projet Antinouri-Nicholas) au Nouveau-Brunswick. Les données concernant ces gisements sont compilées aux fins d'introduction dans la base de données informatisée sur les gîtes minéraux. Parmi ces gisements connus et nouveaux, 54 ont fait l'objet de vérification sur le terrain.

A review of all new assessment files, a number of old assessment files, and miscellaneous department files has located a number of mineral occurrences that are not listed in the N.B. computerized mineral occurrence database. These data are currently being compiled and will be entered into the database, along with data from new occurrences in the Antinouri-Nicholas project area, for release in April 1992. There will be approximately 150 new occurrences added to the file and 146 mineral occurrences will have been updated. Exact locations for these mineral occurrences are being determined and entered into the Province's GIS system for printout at any map scale and in conjunction with any other geoscience survey on file. A new subfile is being added to the N.B. computerized mineral occurrence file for the occurrences detailed for the Antinouri-Nicholas project and will eventually be extended to include all the occurrences in the Province. This subfile will give a textual description of the occurrence, compiled from archived data and from data collected during site visits. A reference file is also being compiled. An example of a printout from this subfile is given in Figure 7. This file also lists sample numbers cross-referenced to the outcrop field notes, thin section descriptions and geochemical analyses that are also computer archived. A 1:12 500 sketch map is also listed in the subfile. These sketches use the 1:12 500 colour aerial photographs as a base and can be found in the hard-copy mineral occurrence files located in Fredericton, Sussex, and Bathurst. These hard-copy files also contain much of the data used to derive the textual descriptions. Available aerial photographs and orthophotographs are also listed. An additional interpretative section will probably be added to this subfile.

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[10]The objective of this project is to provide the mineral exploration industry with a mineral occurrence database for the region, and formulate geological models useful in mineral resource exploration.

0901
Visited
ELMTREE No. 13 (OLD SILVER MINE)

LITERATURE DESCRIPTION:

Bailey (as quoted in the Elmtree Silver Mining Company prospectus) remarks that "....on an old Nova Scotia map, made before the separation of the provinces, there is lead marked as occurring in this vicinity" (Elmtree Silver, 1882). The Elmtree Silver Mining Company was incorporated in 1882 to explore and develop the Elmtree showing. The discoverer of the showing is unknown. The vein was exposed in the bed of the Elmtree River and clearly visible. Assays at the time ranged up to 71.1% lead, 33 3/4 oz/t silver and 23.3 dwts/t gold for a value of $132.90/ton at 1882 prices (company prospectus). The deposit had been examined in January 1881 by Edward Jack. He stated "the breadth of this vein is from six to seven feet: the South wall is of slate and the North, so far as could be observed, is of whinstone. The gangue is of quartz. In the centre of the vein there appeared to be two and one half feet in width of the country rock....".

The deposit is documented in the GSC's Report of Progress for 1880-82 (GSC, 1882a and GSC, 1882b). They report that a shaft had just recently been started on a vein that "....is much better defined than on the Nigadoo, and has a width of from six to seven feet, often brecciated and porphyritic, carrying galena, blende, iron pyrites and sulphuret of copper, associated with quartz and calcite." They believed that the Nigadoo and Elmtree deposits were possibly on the same vein system as their strike is similar. An analysis of an ore sample gave 7.197 oz/t silver and a trace of gold in a sample composed of 50.2% sulphides. No details on the shaft can be found other than a 1909 survey (Fish, W.E., 1909) which indicates that it was 66 feet deep and Hardman's report (below, Hardman, 1892) which mentioned that the vein was intersected at 23 feet depth and from a crosscut from the bottom of the shaft.

A long report in the 32nd. Annual Report of the Department of Lands and Mines (Hardman, 1892) shows that the company had run out of money and was appealing to the government for financial aid. Aid was apparently granted (to the value of $750 according to Hale, W.E., 1961, or $1500 according to the 32nd. Annual Report) and the value and work carried out were documented. In John Hardman's 1892 submission is the following description of the showing exposed as an 8 foot long cut into the north bank of the Elmtree River: "The vein as exposed by the cutting ..... has a width of from 7 to 8 feet, but is divided into three distinct zones. The first of these zones, that lying immediately below the hanging–wall consists of a quartz gangue from 22 to 26 inches wide, carrying cubes of galena, crystallized and granular sphalerite or zinc blende with associated iron pyrites; disseminated through the gangue, also occur chlorite and some calc. spar. This hanging-wall lode ".... is undoubtedly the main ore-bearing portion or pay-streak of the vein and is alone sufficiently promising to warrant further development. The second or middle zone occupies a width varying from 3 to 4 feet and is a hard calcareous slate, more or less mineralized, with pyrite and galena. This mineralization does not show at the grass roots, but first appears four or five feet below. It is possible that this middle zone is accidental in character, and belongs to that class of disturbance which in mining parlance is called a horse, i.e.– a portion of the country rock which by accident has become imbedded in the vein mass. This view is strengthened by the fact that there is a seam or parting at the surface which is distant about eight inches from the hanging-wall lode. At three or four feet below the surface, this seam becomes filled with about one inch of decomposed porphyritic material, which about five feet from the surface turns from its true dip of 67 1/2° N.E. and drops to a nearly vertical angle, cutting the rest of the slate, and eventually meeting a similar seam which constitutes the hanging-wall of the third or foot-wall zone. The cut is not deep enough to actually show the union of the two felspathic seams and hence the character of the middle zone, below the junction is merely conjecture. It is interesting, however, to note that the mineralization of this slaty or middle zone is greatest nearest the junction. Below this middle zone

FIGURE 7. Example of text printout from the Mineral Occurrence File.

lies the third or footwall lode. This zone is peculiar. It has in each wall a seam of this decomposed porphyry, the feldspar of which has been so decomposed as to produce a fine white clay closely resembling kaolin, whilst rounded pebbles of greenish quartz remain undisturbed and imbedded therein. The hanging-wall seam is about two inches thick, the foot-wall seam varies from two to three and one-half inches. The space between these two felspathic seams measures twenty-two to twenty-four inches and is filled with an argillaceous and calcareous rock very similar to the calcareous slate of the middle zone, but more highly mineralized and often showing good specimens of galena..... The course of the vein as shown by this opening is N. 40° W. and its dip is 67 1/2° N.E." An assay of silver ran as high as 17 oz. 15 dwt./t and 59% Pb. The submission by Prof. Bartlett recommended further work and remarked on the brecciated nature of some of the ore. Bartlett refers to the vein as "... a true fissure vein.... dipping to the N.E. about 75 degrees.... " with the foot wall well defined and having "... the usual fluccan or gouge common to all fissures".

The 1909 survey map of Fish shows this occurrence to be 4500 feet northwest of the Keymet vein. At this time the area was staked by E.A. Charters. The occurrence is again mentioned in the GSC Annual Reports 1894 and 1897 (GSC, 1894 and Bailey, L.W., 1898b. Young, G.A., 1911b describes the upstream side of the vein as having "...a rather distinct wall where the enclosing slates are little altered. On the downstream side the slates are considerably altered, penetrated by calcite stringers, and partly mineralized so that the boundary of the vein is not distinct."

The deposit is mentioned by McMullen, W.E., 1928, Alcock, F.J., 1930 and Alcock, F.J., 1941. In 1939 one hole was drilled by Dunlop (hole No. 4). According to Raoul Legacy the hole was lost due to caving before it intersected the vein. Keymet drilled holes K-29, 29A and 30 in the late 1940's (Wright, W.J., 1938b, Wright, W.J., 1939, Wright, W.J., 1940 and Wright, W.J., 1937b). No drill logs are available. The holes are compiled on maps by Babin, T., 1982, and Mersereau, T., 1987d and Northeast, 198?. The geology of the area has been compiled by BM&S, 1980, and Gardiner, W.W., 1989. The area has been mapped by (Williams, D.A., 1977) and is currently being remapped (Walker, J., 1991).

FIELD DESCRIPTION:

This occurrence was visited by W.W. Gardiner in 1989. The shaft is still open and poses a hazard as the water level is 2 metres below the surface and the walls are smooth rock. Good ore-grade samples can still be found in the dumps. A number of the trenches are still visible.

SAMPLES COLLECTED (File -OUTCROP1):
89WG027
89WG029
89WG049

THIN AND POLISHED SECTIONS (File- THIN1):
89WG027A
89WG027B
89WG029

GEOCHEMICAL ANALYSES (File- GEOCHEM1.FW3):
89WG049

SKETCHES:
91-34

Orthophoto:
Airphoto: DNR85504-199
NTS: 21P/13c

W.W. Gardiner
July 1991

FIGURE 7. Continued.

MINERAL EXPLORATION STIMULATION PROGRAM[11]

G.W. Crouse
MESP Coordinator

The Mineral Exploration Stimulation Program (MESP) provides financial assistance to mineral exploration companies and prospectors who would like to carry out exploration for minerals within the Province of New Brunswick. Grants are available to anyone holding a valid Mineral Resources Division prospecting licence. The grants can be used to fund expenses such as analyses, meals, and mileage. Wages are not eligible expenses. A committee comprising L.R. Fyffe (Senior Geologist in Fredericton), W.W. Gardiner (Mineral Deposits Geologist), S.R. McCutcheon (Regional Geologist in Bathurst), A.A. Ruitenberg (Regional Geologist in Sussex), D. Hoy (representing the New Brunswick Prospectors and Developers Association), and G. Crouse (MESP Coordinator), reviews the MESP applications and approves those that meet the criteria.

When a MESP grant has been approved, 35% of the grant is awarded on approval. The recipient must submit a brief statement outlining how the initial 35% was spent before receiving the second installment of 35%. To receive the final 30%, sample location maps, analytical results, and travel logs must be submitted. Receipts for any purchases or expenses claimed under MESP must also be submitted. If an individual does not complete his program and does not return unused funds he is not eligible for another grant until he does so.

The Mineral Exploration Stimulation Program has been very popular since its inception in 1988, and each year a number of properties funded by MESP have been optioned to exploration companies.

The MESP committee met in early June, 1991 and reviewed 47 applications for grants. Thirty-nine applications were approved for a total of $65 000. Recipients included; Gerald Alcott, Robert Baxter, Donald Black, Earnest Brooks, James Burns, Fred Cady, Wayne Carroll, William Carter, Peter Coakley, Robert Connor, Reg Cox, Jean Deschenes, William Donovan, Lee Fraser, William Gates, Pius Gaudet, Vital Gaudet, Donald Graham, Ian Graham, Clifford Griffin, Barry Hachey, Owen Hickey, Donald Hoy, Bruce Jack, Delbert Johnston, James Kelly, Raoul Legacy, Charles MacDonald, Patrick Marr, Timothy Mills, David O'Neil, Gaston Paulin, Norman Pitre, Walter Sharpe, Beverly Stewart, Ralph Stewart, Michael Taylor, Michael Trapnell, and Claude Willett.

MESP funds were also used to conduct prospector training courses in Bathurst and Fredericton.

PROGRAMME DE STIMULATION DE L'EXPLORATION MINIÈRE

G.W. Crouse
coordonnateur de PSEM

Le programme de stimulation de l'exploration minière (PSEM) a pour mandat de fournir une aide financière aux sociétés d'exploration minière et aux prospecteurs qui désirent effectuer de la prospection au Nouveau-Brunswick. Des subventions sont offertes à tous les détenteurs d'un permis de prospection valide de la Division des ressources minérales. Les subventions peuvent servir à financer des dépenses telles que les analyses, les repas et les déplacements. Les salaires ne constituent pas des dépenses admissibles. Un comité composé de L.R. Fyffe (géologue principal à Fredericton), W.W. Gardiner (géologue aux gisements minéraux), S.R. McCutcheon (géologue régional à Bathurst), A.A. Ruitenberg (géologue régional à Sussex), D. Hoy

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[11]The Mineral Exploration Stimulation Program, which was initialized in 1988, is one of the incentives initiated to encourage prospecting and exploration in New Brunswick.

(représentant la New Brunswick Prospectors and Developers Association) et G. Crouse (coordonnateur du PSEM) analyse les demandes soumises en vertu du PSEM et il approuve celles qui satisfont aux critères.

Lorsqu'une subvention du PSEM a été approuvée, 35 % de la subvention sont remis au moment de l'approbation. Le bénéficiaire doit soumettre un relevé sommaire indiquant la manière selon laquelle les premiers 35 % ont été investis avant de recevoir le second versement de 35 %. Pour obtenir les derniers 30 %, l'intéressé doit soumettre des cartes de localisation des échantillons, des résultats analytiques et des relevés de déplacement. L'intéressé doit également soumettre des reçus des achats ou des dépenses effectués au titre du PSEM. La personne qui ne termine pas son programme et qui ne retourne pas les fonds inutilisés n'a pas droit à une autre subvention tant qu'elle n'a pas respecté son engagement.

Le Programme de stimulation et d'exploration minière est très populaire depuis son entrée en vigueur en 1988, et chaque année, un certain nombre de propriétés financées par le PSEM sont sélectionnées pour des sociétés d'exploitation.

Le Comité du Programme de stimulation de la prospection minière (PSEM) s'est réuni au début de juin 1991 et a étudié 47 demandes de subvention. Trente-neuf demandes ont été acceptées en vue de l'octroi d'un total de 65 000 $. Les personnes ayant obtenu une subvention sont et Gerald Alcott, Robert Baxter, Donald Black, Earnest Brooks, James Burns, Fred Cady, Wayne Carroll, William Carter, Peter Coakley, Robert Connor, Reg Cox, Jean Deschênes, William Donovan, Lee Fraser, William Gates, Pius Gaudet, Vital Gaudet, Donald Graham, Ian Graham, Clifford Griffin, Barry Hachey, Owen Hickey, Donald Hoy, Bruce Jack, Delbert Johnston, James Kelly, Raoul Legacy, Charles MacDonald, Patrick Marr, Timothy Mills, David O'Neil Gaston Paulin, Norman Pitre, Walter Sharpe, Beverly Stewart, Ralph Stewart, Michael Taylor, Michael Trapnell et Claude Willett.

Des fonds du PSEM ont été utilisés pour offrir un cours de formation pour prospecteurs à Bathurst et à Fredericton.

DRILL-CORE MANAGEMENT PROGRAM[12]

G.W. Crouse
Drill-core Manager

The Geological Surveys Branch of the New Brunswick Department of Natural Resources and Energy maintains drill-core–storage facilities in Fredericton, Bathurst, and Sussex. The Bathurst facility, located approximately 30 km north of Bathurst at Madran, was built in the mid 1970's under a Federal-Provincial DREE Program. The Sussex facility, located behind the Regional Office at Picadilly, was built in the 1980's under the Federal-Provincial Mineral Development Agreement. The Fredericton core-storage-facility was built as part of the Hugh John Flemming Forestry Complex in the late 1980's. The Fredericton facility has a large well-lit viewing-sample preparation room that has been used almost continuously by company and government geologists since it was opened. Logging and sampling of the drill core from the Sewell Brook and Captain North Extension deposits was carried out at the Fredericton facility. The Geological Surveys Branch has also been using the facility to conduct a heavy-mineral-separation program using gold wheels. The field geologists working out of the Fredericton Office also use the facility to prepare their samples. Anyone can use the facilities, the only stipulation being that they must keep the area clean and provide their own saw blades.

The Geological Surveys Branch received approximately 35 583 metres of core during 1991. In Bathurst, 16 483 metres was donated by Corona Corporation and 9040 metres was donated by Marshall Minerals. In Sussex, 10 060 metres of core was collected from Lake George.

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[12]At present, diamond-drilling costs approximately $60 per metre, hence the rock core retrieved is very expensive information. The Province's drill-core retrieval and storage program provides valuable subsurface information for mineral exploration to the private sector.

Inventories were conducted at the Fredericton and Madran core-storage facilities. Databases listing drill core stored by NBDNRE and drill-core information submitted in assessment files were updated. Numerous companies have used the drill-core-storage facilities in the three regions to log and sample core.

PROGRAMME DE GESTION DES CAROTTES DE FORAGE

G.W. Crouse
responsable de la carothèque

La Direction des études géologiques du ministère des Ressources naturelles et de l'Énergie dispose d'installations d'entreposage de carottes de forage à Fredericton, à Bathurst et à Sussex. L'entrepôt de Bathurst, situé à environ 30 km au nord de Bathurst, à Madran, a été construit au milieu des années 1970 en vertu d'un programme fédéral-provincial du MEER. L'entrepôt de Sussex, situé à l'arrière du bureau régional de Picadilly, a été construit au cours des années 1980 en vertu de l'Entente fédérale-provinciale sur l'exploitation minérale. L'entrepôt de carottes de forage de Fredericton a été construit en tant que partie intégrante du Centre forestier Hugh John Flemming vers la fin des années 1980. Il est doté d'une grande salle bien éclairée pour la préparation et l'observation des échantillons, qui a presque constamment été utilisée par les sociétés et les géologues du gouvernement depuis son ouverture. L'enregistrement et l'échantillonnage des carottes de forage des gisements du ruisseau Sewell et de Captain North Extension ont été effectués à l'entrepôt de Fredericton. La Direction des études géologiques utilise également l'entrepôt pour diriger un programme de séparation des minéraux lourds au moyen de roues d'argent. Les géologues sur le terrain qui travaillent à l'extérieur du bureau de Fredericton utilisent également l'entrepôt pour préparer leurs échantillons. N'importe qui peut utiliser les installations, la seule condition étant de maintenir les lieux propres et de se procurer ses propres lames de sciage.

La Direction des études géologiques du ministère des Ressources naturelles et de l'Énergie du Nouveau-Brunswick a reçu environ 35 583 mètres de carottes de forage. À Bathurst, Corona Corporation a fait don de 16 483 mètres, et Marshall Minerals, de 9040 mètres. À Sussex, 10 060 mètres de carottes ont été prélevés au lac George.

On a dressé l'inventaire à l'entrepôt de stockage des carottes de Fredericton et de Madran. Les bases de données renfermant les listes des carottes de forage stockées par le MRNE du N.-B. et les renseignements sur les carottes de forage soumis dans les dossiers d'évaluation ont été mis à jour. Un grand nombre de sociétés ont utilisé les entrepôts de stockage de carottes des trois régions pour enregistrer et prélever des échantillons de carottes.

NOTES

ENERGY BRANCH

MONCTON SUBBASIN INCEPTION[1]

Clint St. Peter
Energy Resources Geologist

Regional studies of the terrestrial Horton Group and, in particular, the Lower Carboniferous Albert Formation in the Moncton Subbasin of southeastern New Brunswick indicate that Horton rocks can be divided into alluvial, fluvial, paludal, and lacustrine lithofacies. Reflection seismic facies analyses help corroborate the subsurface distribution of lithofacies.

The spatial geometry of lithofacies and seismic facies have been collated with surface structural geological observations of Horton Group strata and with stratigraphic and structural interpretations of numerous seismic reflection profiles. The combined data strongly imply that the Moncton Subbasin formed in a dextral strike-slip setting during Late Devonian/Early Carboniferous time.

Les études régionales du groupe terrestre de Horton et, plus particulièrement, de la couche carbonifère inférieure d'Albert dans le sous-bassin de Moncton, au sud-est du Nouveau-Brunswick, ont indiqué que les roches de Horton peuvent être divisées en lithofaciès alluviaux, fluviaux, paludéens et lacustres. Des analyses du faciès de réflexion sismique ont permis de corroborer la distribution souterraine des lithofaciès.

La géométrie spatiale des faciès lithologiques et sismiques a été comparée avec les observations géologiques structurales de la surface des strates du groupe de Horton ainsi qu'avec les interprétations structurelles et stratigraphiques de nombreux profils de réflexions sismiques. Les données combinées suggèrent fortement que le soubassement de Moncton a été formé par un rejet horizontal dextral au cours du dévonien supérieur/carbonifère inférieur.

The Moncton Subbasin (Figure 1) is a substructure of the post-Acadian intermontane Upper Devonian/Carboniferous Maritimes Basin. The Maritimes Basin comprises an area of 148 000 km^2 of which about 70 per cent lies offshore in the Gulf of St. Lawrence (Roliff 1962). A summary of the stratigraphy in the Maritimes Basin has been given by Roliff (1962), Kelley (1967), Hacquebard (1972), and Howie and Barss (1975). Tectonic and plate-tectonic interpretations of the Maritimes Basin and/or its component subbasins have been advanced by Belt (1968), Webb (1969), Fralick and Schenk (1981), Bradley (1982), Knight (1983), Yeo (1985), McCutcheon and Robinson (1987), and Hamblin (1989). Among these authors, Belt (1968) and McCutcheon and Robinson (1987) have argued that the Maritimes Basin developed mainly as a result of rifting; the other authors attribute the basin or its local subbasins to subsidence associated with a broad wrench zone. Evidence from the present study of Horton Group rocks in the Moncton Subbasin of southeastern New Brunswick suggests a strike-slip or wrench setting during the formative stage of basin development (St. Peter, in preparation).

The Moncton Subbasin is 20 to 50 km wide and about 150 km long; it lies upon Precambrian and Lower Paleozoic deformed rocks of the Avalon terrane (Figure 1). Sedimentary fill is mainly terrestrial and up to 6 km thick in the axial part of the Subbasin. The fill comprises three depositional sequences separated by two basin-wide unconformities (Table 1).

The first (basal) depositional sequence is the Horton Group. It consists of a lower redbed unit, the Memramcook Formation, an upper redbed unit, the Weldon Formation, and a medial predominantly grey unit, the Albert Formation (Table 1). The Memramcook and Weldon redbeds include coarse proximal alluvial fanglomerates and fine distal alluvial and fluvial sandstones and mudstones. The Albert Formation comprises a range of lithofacies from proximal alluvial fan conglomerates, fan-delta conglomerates and sandstones, and braided stream conglomerates and sandstones, to more distal marginal lacustrine sandstones and mudstones, perennial to ephemeral saline lake evaporites, and deep lacustrine oil shales.

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[1]This project is part of an on-going study of Carboniferous rocks that host the Province's fossil fuel resources. Results of such work are very useful in the search for new resources.

An interpretation of the spatial relationships of Albert lithofacies at the end of Albert time in the southeastern Moncton Subbasin is shown on Figure 2. The subsurface lithofacies geometry shown on Figure 2 is supported by seismic facies analyses of several tens of kilometres of seismic reflection profiles. In general, the conglomerate facies gives rise to short, irregular, variable amplitude reflectors of poor continuity; interbedded sandstones and mudstones yield continuous to semi-continuous, high-amplitude reflectors; the mudstone facies gives short, lenticular or wavy, irregularly spaced reflectors of low-to-moderate amplitude; and the evaporite facies is characterized by the virtual absence of reflectors (St. Peter, in preparation).

The Horton sequence is unconformably overlain by a second depositional sequence comprising: (1) coarse redbeds of the Hillsborough Formation; (2) marine limestones, sulphates, and chlorides of the Windsor Group and; (3) fine- to coarse-grained redbeds of the Hopewell Group (Table 1). The Hopewell beds are unconformably succeeded by a relatively undeformed and subhorizontally disposed Upper Carboniferous sequence consisting of the Cumberland Group (new usage in New Brunswick) and Pictou Group. For the purpose of the present summary, only evidence from the Horton sequence is given, which bears on the formative stage of development of the Moncton Subbasin.

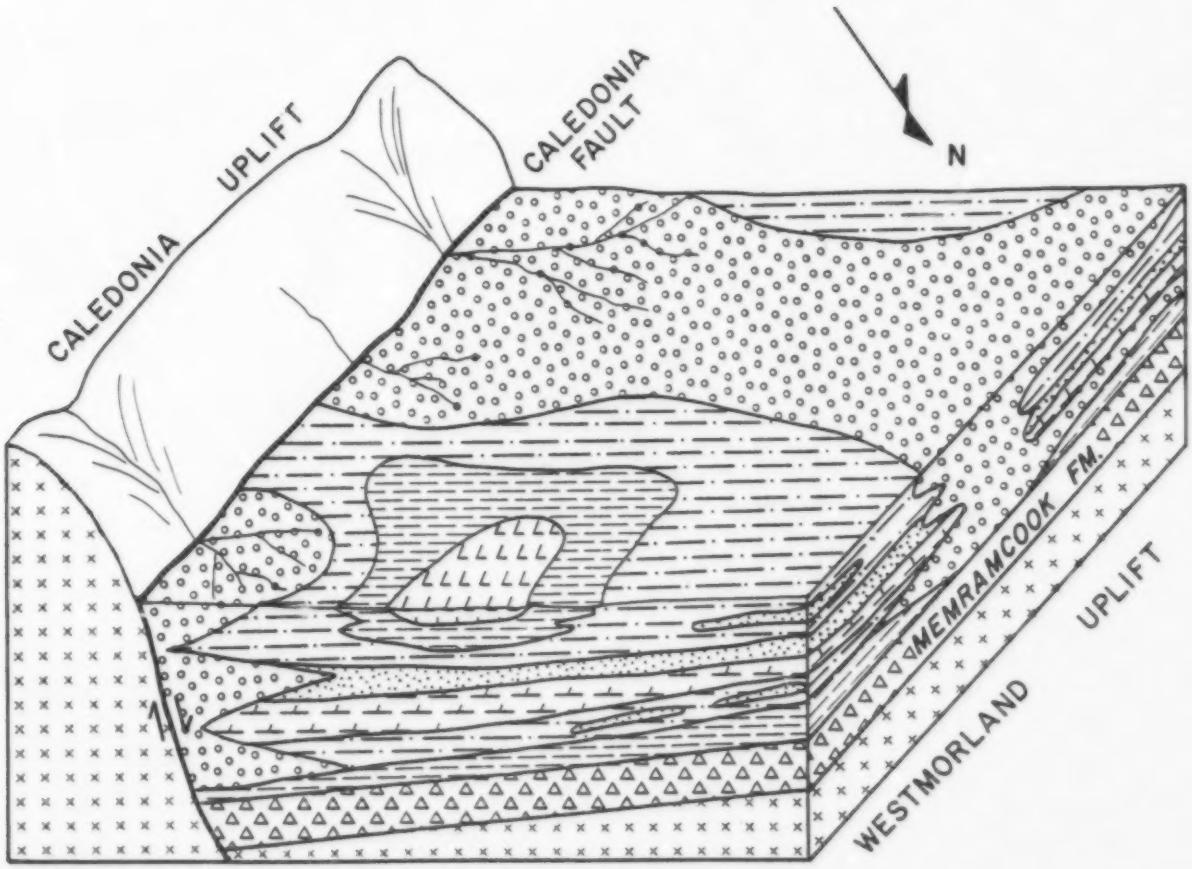

FIGURE 2. Simplified palinspastic block diagram of Albert lithofacies looking southwest in the southeastern Moncton Subbasin at close of Albert time. Lithofacies patterns: open circles (conglomerate facies), dots (sandstone facies), dash-dot (mudstone/sandstone facies), dash (mudstone facies), dash with oblique bar (kerogenous mudstone facies), and L-shapes (evaporite facies).

HORTON DEPOSITIONAL-TECTONIC CYCLE

Formation of the Moncton Subbasin was initiated along basin-bounding faults in Late Devonian time as recorded by deposition of the spore-dated Memramcook Formation. Subsidence continued throughout Early Carboniferous (Tournaisian) with deposition of the Albert and Weldon formations. Lithofacies distributions and paleotransport indicators from the Horton beds indicate that the paleo-depositional margins of the Moncton Subbasin are in part approximated by the present margins (Figure 1). For example, along the southern margin of the Subbasin adjacent to the Caledonia Uplift – Memramcook, Albert, and Weldon lithofacies are predominantly coarse proximal alluvial fan or fan-delta conglomerates on the north side of the Caledonia, Gordon Falls, and Clover Hill faults (Figure 1). Also, on the northern margin of the Subbasin, Memramcook Formation strata along the south side of the Belleisle Fault from Kingston Uplift to Havelock are mainly coarse conglomerates (Figure 1). Paleocurrents in both the southern and northern proximal coarse facies are transverse to the basin margins. Horton lithofacies in the axial part of the Moncton Subbasin are dominantly finer grained alluvial and fluvial mudstones, playa lake evaporites, and lacustrine oil shales. In these facies, transport vectors are mainly directed either NE or SW along the longitudinal axis of the basin. Present data suggest the existence of two Horton depocentres, one between Sussex and the southwestern end of the Westmorland Uplift, and the other between the Westmorland Uplift and Caledonia Fault (Figure 1).

It is not yet known whether the Moncton Subbasin was initiated in a tensional or transtensional setting. Several (three or more) periods of post-Horton Carboniferous to Jurassic movement on basin-bounding faults have eliminated any bedrock or seismic evidence of initial fault displacements. However, the presence of northeast-oriented sandstone dykes in the Albert Formation along the Caledonia and Dorchester faults (Figure 1) seems to exclude a basin origin by transpression.

The Horton depositional-tectonic cycle clearly ended as the result of a dextral transpressive event. This is evidenced by a series of northeast-trending anastomosing faults associated with the Clover Hill, Gordon Falls, Belliveau Village, Caledonia, and Berry Mills faults (Figure 1; see also St. Peter and Fyffe (1990) and St. Peter (in preparation). Outcrop evidence of right-lateral fault offsets include asymmetric folds, displaced veins, displaced sandstone dykes, right-handed en échelon folds, and a compressional duplex associated with the Gordon Falls Fault (St. Peter, in preparation). Positive flower structures are seen on numerous seismic reflection profiles across the strike-slip fault zones (Figure 3). Uplift and erosion associated with the transpression resulted in the pre-Hillsborough Formation unconformity (Table 1).

In summary, Horton Group terrestrial facies architecture, provenance data, and paleotransport indicators combined with outcrop and seismo-tectonic evidence strongly suggest that the formative stage in the development of the Moncton Subbasin resulted from a dextral transcurrent strike-slip cycle (Reading 1980).

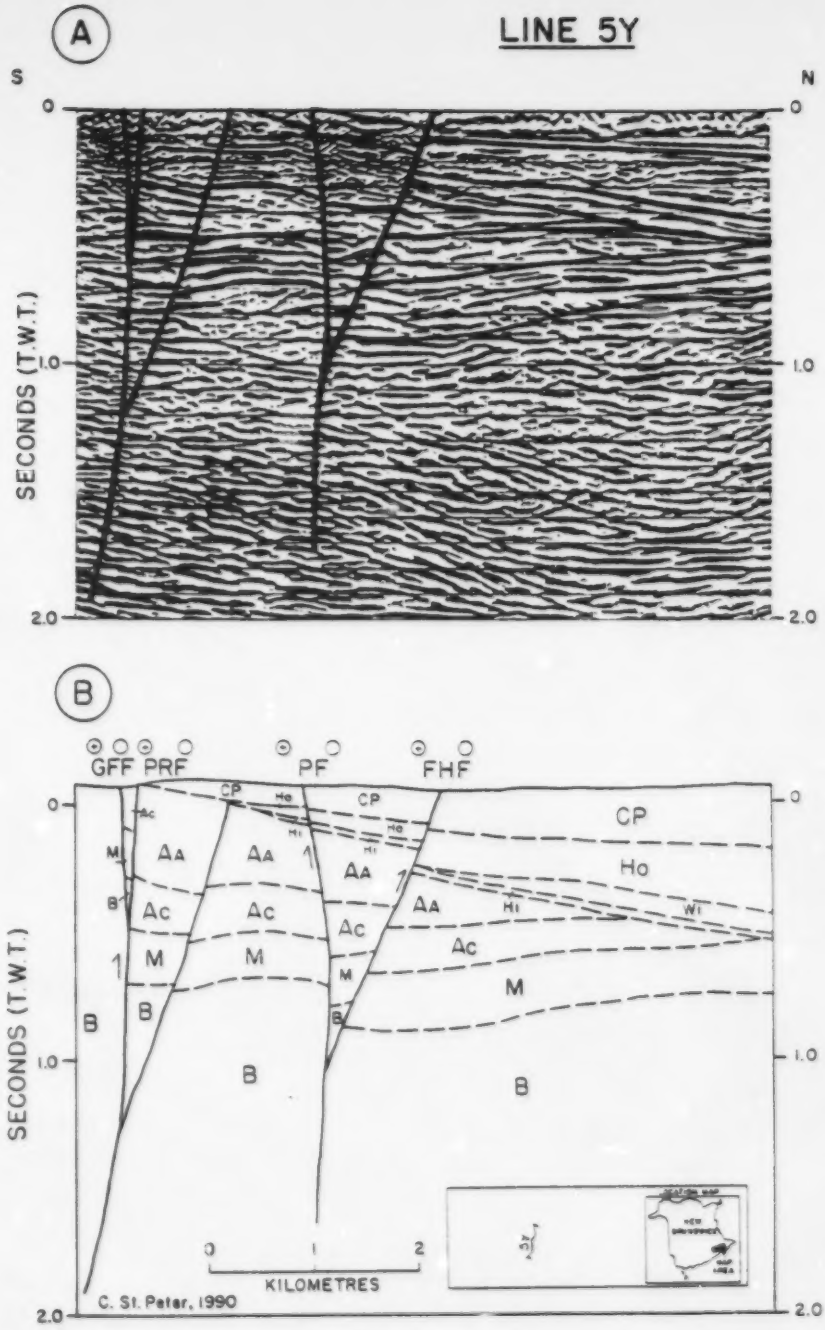

FIGURE 3. Chevron Canada Resources Limited seismic line 5Y (migrated, 3000%). A: Interpreted boundaries of seismic sequences, seismic facies, and faults; B: Geological interpretation; Symbols; B = Basement complex, M = Memramcook Fm., A_A = Albert Fm. (interbedded clastic facies undivided), A_C = Albert Fm. (fine-grained facies), Hi = Hillsborough Fm., Wi = Windsor Gp., Ho = Hopewell Gp., CP = Cumberland and Pictou Gps. GFF = Gordon Falls Fault, PRF = Pollett River Fault, PF = Parkindale Fault, FHF = Forest Hill Fault, circled plus and circled dot = away from and toward sense of transcurrent movement on fault (respectively).

TABLE 1. TABLE OF FORMATIONS
Southeastern Moncton Subbasin and Sackville Subbasin, New Brunswick

ERA	SYSTEM/SERIES	STAGE	GP	FORMATION	LITHOLOGY
PALEOZOIC	UPPER CARBONIFEROUS	STEPHANIAN	PICTOU	Undivided Formations	Grey to red, fine-to coarse-grained, lithic or feldspathic and locally quartzose sandstones, grey to red, polymictic and locally quartz-pebble conglomerate, red to locally grey shale and mudstone, minor calcrete, and coal seams.
		WESTPHALIAN	CUMBERLAND	Boss Point	Grey to yellowish grey quartzose sandstone, rounded quartz-pebble conglomerate, minor red sandstone, red and grey mudstone, calcrete, and coal seams.
				Enrage	Red to locally grey conglomerate, fine-to coarse-grained sandstone; minor mudstone and calcrete.
		NAMURIAN	HOPEWELL	Shepody	Grey to red, fine-grained, laminated sandstone, red mudstone, very coarse-grained sandstone; minor conglomerate and grey mudstone.
				Maringouin	Red mudstone; minor ripple laminated sandstone.
	LOWER CARBONIFEROUS	VISEAN	WINDSOR	Clover Hill	Nodular, to mosaic and massive anhydrite, salt and claystone.
				Cassidy Lake	CASSIDY LAKE: Colourless to orange-brown, medium-to coarse-grained halite, red sylvinite; minor claystone and anhydrite.
				Upperton	UPPERTON: Grey to white gypsum at surface, nodular to mosaic anhydrite; minor stratified anhydrite.
				Gays River	MACUMBER: Grey to black intraclastic or pelletoidal wackestone and packstone; minor floatstone and intraformational breccia.
				Macumber	GAYS RIVER: Grey to black, laminated to thickly bedded algal boundstone; minor wackestone, packstone and basal bafflestone.
				Hillsborough	Red to grey granule to cobble polymictic conglomerate, red to grey lithic sandstone; minor red mudstone.
		TOURNAISIAN	HORTON	Weldon / Boyd Creek Tuff	Red to locally grey mudstone, fine-to coarse-grained sandstone, granule to boulder polymictic conglomerate; minor calcrete and gypcrete. BOYD CREEK TUFF: Light pink to purple or dark grey felsic crystal-lithic tuff.
				Albert	Grey and minor red mudstone and shale, grey and minor red, fine-to coarse-grained feldspathic and lithic sandstone, grey and minor red granule to boulder polymictic conglomerate; minor kerogenous mudstone, kerogenous shale, nodular limestone, oncolitic limestone, dolostone, rock salt, anhydrite, and glauberite.
	UPPER DEVONIAN	FAM. / FRAS.		Memramcook	Red to grey, granule to boulder polymictic conglomerate; red to locally grey fine-grained to pebbly feldspathic and lithic sandstone, red mudstone; minor calcrete.
	PRE-UPPER DEVONIAN			Basement Complex	Deformed to polydeformed sedimentary, metasedimentary, volcanic, and metavolcanic rocks; massive to deformed intrusive rocks.

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GEOLOGICAL SURVEYS BRANCH

GEOSCIENTIFIC EDITORIAL SERVICES SECTION

ACTIVITIES OF THE GEOSCIENTIFIC EDITORIAL SERVICES SECTION

B.M.W. Carroll
Geoscience Editor

The Geoscientific Editorial Services Section includes the following staff members: Barbara M.W. Carroll (Geoscience Editor), Shasta A. Abbott (Assistant Geoscience Editor, C-NBCAMD), and Kim Stewart (Report Typist, C-NBCAMD).

The responsibility of this section is to edit all geoscientific reports and maps that are produced by or for the Mineral Resources Division.

Following is the list of reports and maps released by the Division in 1991.

ACTIVITÉS DE LA SECTION DES SERVICES D'ÉDITION DE L'INFORMATION GÉOSCIENTIFIQUE

B.M.W. Carroll
rédactrice en chef, géoscience

La Section des services d'édition de l'information géoscientifique comprend le personnel suivant: Barbara M.W. Carroll (rédactrice en chef, géoscience), Shasta A. Abbott (rédactrice en chef adjointe, géoscience, ECCNBEM), et Kim Stewart (dactylo; ECCNBEM).

Cette Section est chargée d'éditer tous les rapports et cartes géoscientifiques produits par ou pour la Division des ressources minérales.

On trouvera ci-dessous la liste des rapports et des cartes publiés par la Division en 1991.

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NOTES

GEOLOGICAL SURVEYS BRANCH

BATHURST REGIONAL OFFICE

ACTIVITIES OF THE BATHURST REGIONAL OFFICE[13]

S.R. McCutcheon
Regional Geologist

The staff of the Bathurst Regional Office consists of Steven McCutcheon (Regional Geologist), John Langton (Assistant Regional Geologist), Sharon McKinnon (Administrative Officer and Deputy Recorder), André LeBlanc and Maurice Belland (Engineering Technicians). Mike Parkhill and James Walker are contract geologists responsible for projects funded through the C-NBCAMD. Susan Gower, Janice LeBlanc, David Bance, Doug Clark, and Peter Banks were hired as summer personnel. David Lentz, who is a contract geologist (C-NBCAMD) with the Geological Survey of Canada, started in June and will be working at the Bathurst Office for the next three years.

PROJECTS

The **Antinouri-Nicholas project** was initiated as a 5-year program, but limited C-NBCAMD funding allows for only three years of field work. The project area (about 900 km²) extends from Jacquet River in the northwest to Robertville in the southeast, and encompasses the mineral occurrences/deposits in the vicinity of a largely blind Devonian intrusive suite that lies to the northwest of Bathurst. This project is an integrated s consisting of several sub-projects. Geological mapping was completed last year at 1:20 000 scale in map a 21 O/16a and 21 P/13d (Walker *et al.* 1990) and continued this year in map areas 21 P/12e, 12f, 12g, 21 P/ and 13c (Walker *et al.*, this volume). Mineral occurrence studies began last year (Gardiner 1990) and continued this year. Approximately two/thirds of 243 mineral occurrences have been field checked and 100 have b sampled (Gardiner, this volume). Compilation of assessment data was also started last year (Rennick 1990) to date map areas 21 P/12e, 21 P/13d, and 21 O/16a have been completed and work is progressing on 21 P/12f, 12g, and 21 P/13c (Rennick, this volume).

In order to provide age constraints on the intrusive activity, samples were submitted to M.L. Bevier at the GSC Geochronology lab for radiometric dating. U-Pb ages of 381 ± 4 Ma and 372 ± 4 Ma were obtained from the Nicholas Dénys Granodiorite (tonalite) and the Antinouri Lake Granite, respectively (see Walker *et al.*, this volume). A gravity survey, about 25 line-kilometres, was conducted (under contract) in the northern part of the Nigadoo Synclinorium by Northeast Exploration Services. The objectives were to determine if the Nigadoo Porphyry has a gravity expression and to establish a gravity profile across the area where Devonian intrusions occur (see Walker *et al.*, this volume). The resulting digital data will be incorporated into the on-going gravity modelling of M.D. Thomas at the GSC Geophysics Division.

The **California Lake till-sampling project** began last year (Parkhill 1990) under the C-NBCAMD. This year M. Parkhill, assisted by D. Bance, completed the regional sampling and surficial mapping of 21 O/8 (see Parkhill, this volume). Duplicate samples were collected for Noranda Technology at a number of sites for geotechnical testing. In addition, detailed sampling was carried out around the Halfmile Lake base-metal deposit in anticipation of future developments at this locality. Providing funds are available, till sampling will be conducted over 21 P/5W next year.

The **Brunswick project** is a provincially funded study of Tetagouche Group rocks that overlie and underlie the "Brunswick horizon". The objectives of the study are to 1) define the internal stratigraphy of the felsic volcanic pile, 2) determine if there are one or more ore-bearing horizons, and 3) show its (their) distribution on 1:10 000- and 1:20 000-scale geological maps and sections. The original project area was limited to the Brunswick No. 6 open-pit mine site, but it will ultimately encompass most of 21 I W, Nepisiguit Falls

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[13]The Bathurst Regional Office is the base for geoscience projects in northern New Brunswick. Staff members are involved in the planning and execution of "A" and C-NBCAMD programs, and are responsible for interpreting the results. Geoscientific consulting services are provided as required by the mineral industry and the public.

(McCutcheon *et al.* 1989). Last year, the results of preliminary geological mapping in map areas 21 P/5-101, 102, 201, and 202 were reported (Langton and McCutcheon 1990). This year, J. Langton, assisted by P. Banks, extended the mapping into 21 P/5-103, 203, 301, 302, and 303 (see Langton, this volume).

DIAMOND-DRILL CORE

In 1991, Corona Corporation closed their Bathurst office and turned over all of their drill core to the Mineral Resources Division. About 16 483 metres of core was moved to Madran. In addition, 9040 m of core from Marshall Minerals' definition drilling program at the Restigouche deposit was taken to Madran.

OTHER ACTIVITIES

S. McCutcheon edited a group of eight papers on the geology and mineral deposits of the Bathurst Camp. These papers were presented at the Base Metal Symposium held in Bathurst last year and will be published in the second issue of Exploration and Mining Geology, the new journal of the Geological Society of the CIM, toward the end of this year. A paper by S.R. McCutcheon and M.L. Bevier was published recently in Atlantic Geology describing the timing of deformation and gold mineralization in the Upsalquitch area of northern New Brunswick. S. McCutcheon and M. McLeod made final corrections to two papers that describe the geology of Late Precambrian and Early Paleozoic rocks in southern New Brunswick. These papers will eventually be published by the Geological Survey of Canada in Chapter 3 of "Geology of the Appalachian/Caledonian Orogen in Canada and Greenland", edited by H. Williams.

S. McCutcheon was part of the selection committee that reviewed applications for funding under the Mineral Exploration Stimulation Program (MESP). He reviewed several EIA draft reports for the New Brunswick Department of the Environment. He also attended the sectorial-table meetings, as a resource person for the Mining Sector, involved with planning the economic development conference for the Chaleur Region.

Field trips were made to mineral properties held by the following companies and prospectors: Brunswick Mining & Smelting, Falconbridge, Noranda, NovaGold, Teck, BHP Utah, Northeast Exploration, E. Brooks, W. Carroll, R. Legacy, and W. Hachey. Informal trips were provided for a number of company geologists.

Poster displays were taken to the Atlantic Geoscience Society Annual Meeting in Amherst. J. Walker, S. Gower, and S. LeBlanc presented a display entitled: "Siluro-Devonian tectonostratigraphic relationships, western margin of Elmtree inlier, northern New Brunswick". M. Parkhill presented another entitled: "Surficial geology of the Nepisiguit Lakes map area, emphasizing till clast composition, Miramichi Highlands, north-central New Brunswick". The abstracts for these posters will be published in Volume 27 of Atlantic Geology. M. Parkhill presented a poster entitled: "Surficial geology of the Nepisiguit Lakes and California Lake areas, Miramichi Highlands, northern New Brunswick" at the Canadian Quaternary Association (CANQUA) annual meeting in Fredericton; he was joint author of a talk given by A. Seaman entitled: "Quaternary geology of New Brunswick: seven years later". J. Langton prepared part of the display that was taken to the Prospectors and Developers annual meeting in Toronto. He has also undertaken the preliminary work for the GAC/MAC '92 field trip that will come to the Bathurst Camp next spring, including preparation of the guidebook.

J. Walker and M. Parkhill participated in a job shadowing program for students of Bathurst High School. They also took part in a career expo at Bathurst Junior High School along with J. Langton.

Geological advice was provided to many exploration geologists and prospectors. Furthermore, M. Parkhill provided help to a number of engineering firms (including Roy Consultants and Noranda Technology), who were interested in finding solid waste disposal sites and/or cover materials for tailings and waste rock. S. McCutcheon and J. Walker inspected the bedrock foundation to N.B. Power's Belledune River dam site at the request of Acres International, a geotechnical consulting firm hired by N.B. Power. S. McKinnon, A. LeBlanc, and M. Belland provided support services to explorationists and the geological staff in their usual efficient manner.

ACTIVITÉS DU BUREAU RÉGIONAL DE BATHURST

S.R. McCutcheon
Géologue régional

Le personnel du bureau régional de Bathurst est composé de Steven McCutcheon (géologue régional) et John Langton (géologue régional adjoint), de Sharon McKinnon (agente administrative et archiviste adjointe) et de André LeBlanc James Walker (technicien en génie civil). Mike Parkhill James Walker sont des géologues contractuels chargés des projets financés par l'ECCNBEM. Susan Gower et Janice LeBlanc, et David Bance, Doug Clark et Peter Banks ont été engagés à titre d'employés d'été. David Lentz, qui est un géologue contractuel (ECCNBEM) avec la Commission géologique du Canada, est entré en fonctions en juin, et il travaillera au bureau de Bathurst pendant les trois prochaines années.

PROJETS

Le **projet Antinouri-Nicholas** a été amorcé comme projet quinquennal, mais le financement limité accordé par l'ECCNBEM ne permet que trois années de travail sur le terrain. La région d'étude (environ 900 km^2) s'étend de Jacquet River, au nord-ouest, jusqu'à Robertville, au sud-est, et elle englobe les venues/gîtes minéraux à proximité d'une paragénèse intrusive du Dévonien largement aveugle qui s'étende jusqu'au ouest de Bathurst. Ce projet est une étude intégrée regroupant plusieurs sous-projets. Les travaux de cartographie géologique ont été effectués l'année dernière à l'échelle de 1/20 000 dans les secteurs topographiques 21 O/16a et 21 P/13d (Walker *et coll.* 1990), et ils se sont poursuivis cette année dans les secteurs topographiques 21 P/12e, 12f, 12g, 21 P/13b et 13c (Walker *et coll.*, ce volume). Des études sur les venues minérales ont débuté l'année dernière (Gardiner 1990) et elles se sont poursuivies cette année. Environ les deux tiers des 243 venues minérales ont été vérifiées sur le terrain, et une centaine ont été échantillonnées (Gardiner, ce volume). La compilation des données d'évaluation a également été amorcée l'année dernière (Rennick 1990); jusqu'à maintenant, les secteurs topographiques 21 P/12e, 21 P/13d et 21 O/16a ont été terminées et les travaux sont sur les secteurs 21 P/12f, 12 g et 21 P/13c (Rennick, ce volume) en cours.

Afin de fournir des contraintes d'âges sur l'activité intrusive, des échantillons ont été soumis à M.L. Bevier, au laboratoire de géochronologie de la CGC, en vue d'obtenir une datation radiométrique. On a obtenu les âges de l'U-Pb de 381 ± 4 Ma et de 372 ± 4 Ma de la granodiorite (tonalite) de Nicholas-Denys et du granit de lac Antinouri, respectivement (Walker *et coll.*, ce volume). La Northeastern Exploration Services a réalisé une étude de la gravité sur environ 25 kilomètres linéaires (en vertu d'un contrat) dans la partie nord du synclinorium de Nigadoo. Elle avait pour objectifs de déterminer si le porphyre de Nigadoo a une expression de gravité et d'établir un profil de la gravité partout dans la région où se manifestent des intrusions du Dévonien (Walker *et coll.*, ce volume). Les données numériques qui en découleront seront incorporées à la modélisation de la gravité permanente de M.D. Thomas, à la division de géophysique de la CGC.

Le **projet d'échantillonnage des moraines du lac California** a débuté l'année dernière (Parkhill 1990) grâce à l'EEM. Cette année, M. Parkhill, aidé de D. Bance, a terminé l'échantillonnage régional et les travaux de cartographie superficielle du secteur topographique 21 O/8 (Parkhill, ce volume). Des échantillons répétés ont été recueillis à l'intention de la Noranda Technology à un certain nombre de sites en vue d'essais géotechniques. De plus, un échantillonnage détaillé a été effectué autour du gîte de métaux communs du lac Halfmile en prévision d'exploitations futures dans cette localité. Si des fonds sont disponibles, on entreprendra l'année prochaine l'échantillonnage des moraines dans le secteur cartographique 21 P/5W.

Le **Projet Brunswick** consiste en une étude financée par la province sur les roches du groupe de Tetagouche sus-jacentes et sous-jacentes à l'«horizon Brunswick». L'étude a pour objectifs 1) de définir la stratigraphie interne de la structure felsique volcanique, 2) de déterminer s'il existe un ou plusieurs horizons de minerai, et 3) d'indiquer leur répartition sur des cartes et des sections géologiques à l'échelle de 1/10 000 et de 1/20 000. La région initiale du projet était limitée à la mine à ciel ouvert Brunswick n° 6, mais elle englobera en définitive la majeure partie des chutes Nepisiguit, secteur topographique 21 P/5w (McCutcheon *et coll.* 1989). L'année dernière, on avait fourni les résultats des travaux préliminaires de cartographie dans les

secteurs topographiques 21 P/5-101, 102, 201 et 202 (Langton et McCutcheon 1990). Cette année, J. Langton, aidé de P. Banks, ont étendu les travaux de cartographie aux secteurs 21 P/5-103, 203, 301, 302 et 303 (Langton, ce volume).

CAROTTES DE FORAGE

En 1991, la Corona Corporation a fermé son bureau de Bathurst et a confié toutes ses carottes de forage à la Division des ressources minérales. Environ 16 483 mètres de carottes ont été transférées à Madran. De plus, 9040 mètres de carottes du programme de forage de délimitation de la Marshall Minerals ont été transférés du gîte de Restigouche à Madran.

AUTRES ACTIVITÉS

S. McCutcheon a préparé un ensemble de huit documents sur la géologie et les gîtes minéraux du camp Bathurst. Ces documents ont été présentés au colloque sur les métaux communs qui s'est tenu l'année dernière à Bathurst, et ils seront publiés, vers la fin de cette année, dans le deuxième numéro d'«Exploration and Mining Geology», nouveau journal de la Société géologique de l'ICM (Institut canadien des mines et de la métallurgie). Un document préparé par S.R. McCutcheon et M.L. Bevier a récemment été publié dans l'«Atlantic Geology». Il décrit le moment de la déformation et la minéralisation de l'or propre à la région d'Upsalquitch, au nord du Nouveau-Brunswick. S. McCutcheon et M. McLeod ont apporté les corrections finales à deux documents décrivant la géologie des roches du Précambrien supérieur et du Paléozoïque inférieur, au sud du Nouveau-Brunswick. Ces documents seront finalement publiés par la Commission géologique du Canada au Chapitre 3 de «Geology of the Appalachian/Caledonian Orogen in Canadan and Greenland» (Géologie de l'orogène appalachienne/calédonienne au Canada et au Groenland), préparé par H. Williams.

S.M. McCutcheon a fait partie du comité de sélection qui a étudié les demandes de subvention au titre du Programme de stimulation à l'exploration minière (PSEM). Il a analysé plusieurs rapports provisoires d'EIE à l'intention du ministère de l'Environnement du Nouveau-Brunswick. Il a également assisté à titre de personne-ressource pour le secteur minier, aux réunions à la table sectorielle, engagée dans la planification de la conférence sur le développement économique de la région de Chaleur.

Des excursions sur le terrain ont été effectuées dans des propriétés minières tenues par les sociétés et les prospecteurs suivants : la Brunswick Mining and Smelting, la Falconbridge, la Noranda, la Tech, la BHP Utah, la Northeast Exploration et E. Brooks, W. Carroll, R. Legacy et W. Hachey. Des excursions informelles ont été organisées pour un certain nombre de géologues d'entreprises.

Des présentations ont été apportées à la réunion annuelle de l'Atlantic Geoscience Society tenue à Amherst. J. Walker, S. Gower et J. LeBlanc ont présenté une session intitulée «Siluro-Devonian tectonostratigraphic relationships, western margin of Elmtree inlier, northern New Brunswick» (Relations tectonostratigraphiques siluro-dévoniennes, bordure occidentale de l'insertion d'Elmtree, nord du Nouveau-Brunswick). M. Parkhill a présenté une autre session intitulée «Surficial geology of the Nepisiguit Lakes map area, emphasizing till clast composition, Miramichi Highlands, north-central New Brunswick» (Géologie superficielle de la région cartographique de Nepisiguit Lakes, axée sur la composition clastique des moraines, collines de Miramichi, centre nord du Nouveau-Brunswick). Des résumés de ces sessions seront publiés dans le Volume 27 d'Atlantic Geology. M. Parkhill a présenté une affiche intitulée «Surficial geology of the Nepisiguit Lakes and California Lake area, Miramichi Highlands, northern New Brunswick» (Géologie superficielle de la région du lac Nepisiguit et du lac California, collines de Miramichi, nord du Nouveau-Brunswick) à la réunion annuelle de l'Association canadienne pour l'étude du Quaternaire (CANQUA), tenue à Fredericton. M. Parkhill a été co-auteur d'un exposé donné par A.A. Seaman, intitulé «Quaternary geology of New Brunswick: seven years later» (La géologie du Quaternaire au Nouveau-Brunswick : Sept ans plus tard). J. Langton a préparé une partie de la présentation donnée à l'assemblée annuelle des prospecteurs et des entrepreneurs, tenue à Toronto. Il a en outre entrepris les travaux préliminaires en vue de l'excursion sur le terrain de 1992 de l'AGC/AMC (Association géologique du Canada/Association minéralogique du Canada) qui sera présente au camp Bathurst, le printemps prochain, ainsi que la préparation du guide.

J. Walker et M. Parkhill ont participé à un programme de vulgarisation sur les carrières à l'intention des étudiants de l'école secondaire de Bathurst. Ils ont en outre participé à une exposition d'orientation professionnelle tenue à l'école secondaire de premier cycle de Bathurst, en collaboration avec J. Langton.

Des conseils géologiques ont été donnés à un grand nombre de prospecteurs et de géologues prospecteurs. Par ailleurs, M. Parkhill a fourni de l'aide à un certain nombre de firmes d'ingénierie (y compris Roy Consultants et la Noranda Technology), qui souhaitaient trouver des sites d'élimination des déchets solides, ou des matériaux de couverture pour les résidus et les stériles. À la demande d'Acres International, firme de consultants géotechniques engagée par Énergie NB, S. McCutcheon et J. Walker ont inspecté la fondation des dépôts rocheux du site du barrage de la rivière Belledune d'Énergie NB. Avec leur efficcité habituelle, S. McKinnon, A. LeBlanc et M. Belland ont fourni des services de soutien à des prospecteurs et au personnel de géologie.

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BRUNSWICK PROJECT
21 P/5 (WEST HALF)
GLOUCESTER COUNTY, NEW BRUNSWICK[14]

J.P. Langton
Assistant Regional Geologist

The Brunswick Project is part of an ongoing provincially funded study to determine the stratigraphic and depositional setting of the major base-metal deposits of the Bathurst Camp in northern New Brunswick. To date the project has involved the study of the structure, petrography and chemical composition of rocks in the area of the Brunswick No. 6 and No. 12 massive sulphide deposits (21 P/5 west). Four preliminary geology maps have been compiled: 21 P/5-101, -102, -201, and -202. Work on maps 103, 203, 301, 302, and 303 is in progress. Previous data from the area have been re-interpreted utilizing the latest stratigraphical and structural interpretations of the Bathurst Camp, and new chemical analyses of felsic volcanic rocks of the Nepisiguit Falls and Flat Landing Brook formations. The results of the chemical analyses indicate a potential for distinguishing between the two formations on the basis of heavy rare-earth-element concentration.

Le projet Brunswick fait partie intégrante d'une étude permanente financée par la province en vue de déterminer le milieu stratigraphique et sédimentaire des principaux gisements de métaux communs du camp Bathurst, au nord du Nouveau-Brunswick. Jusqu'à maintenant, le projet a comporté l'étude de la structure, de la pétrographie et de la composition chimique des roches dans la région des gisements de sulfures massifs Brunswick n^{os} 6 et 12 (21 P/5 ouest). Quatre cartes géologiques provisoires ont été compilées : 21 P/5-101, -102, -201 et -202. Des travaux sont en cours sur les cartes 103, 203, 301, 302 et 303. Des données antérieures sur la région ont été interprétées en utilisant les dernières interprétations stratigraphiques et structurales du camp Bathurst, et de nouvelles analyses chimiques de roches volcaniques felsiques provenant des formations des chutes Nepisiguit et du ruisseau Flat Landing. Les résultats de ces analyses révèlent un potentiel permettant de faire une distinction entre les deux formations sur la base d'une forte concentration d'éléments des terres rares.

INTRODUCTION

Geological mapping of the southwest quarter of NTS map area 21 P/5 (Figure 8) was initiated in 1990 (Langton and McCutcheon 1990) and will ultimately encompass all of 21 P/5 west. This year, detailed (1:10 000) form-surface and geological mapping of the area to the south and southwest of the Brunswick No. 6 deposit was undertaken. Four, 1:10 000 scale, preliminary geology maps have been completed, (NTS map sheets: 21 P/5-101; 102; 201; 202). Mapping of 21 P/5-301, 302, 303, 203, and 103 is in progress. A compilation of maps 101, 102, 201, and 202 is shown in Figure 9. The lithogeochemical sampling program, begun in 1989, was extended into the present study area (Figure 8), with the aim of identifying compositional variations within pyroclastic/epiclastic rocks of the Nepisiguit Falls (NF) Formation and rhyolites and related volcanic rocks of the Flat Landing Brook (FLB) Formation. In the vicinity of the Brunswick No. 6 and 12 mines, the NF Formation and FLB Formation are respectively referred to as "foot-wall" and "hanging-wall" rocks. The ore-bearing "Brunswick"-horizon is typically situated in fine-grained sedimentary rocks, at or near the top of the NF Formation, and is generally overlain by rhyolites of the FLB Formation (*e.g.*, Brunswick No. 6). However, in places (*e.g.*, Brunswick No. 12), sedimentary rocks and hyaloclastites overlie the NF Formation and may be part of the FLB Formation (Figure 8). These sedimentary rocks are also lithologically similar to those of the Boucher Brook (BB) Formation.

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[14]The Brunswick project provides invaluable geological data for mineral exploration in the Bathurst-Newcastle mining area. The results will allow private companies and prospectors to locate target areas for detailed exploration.

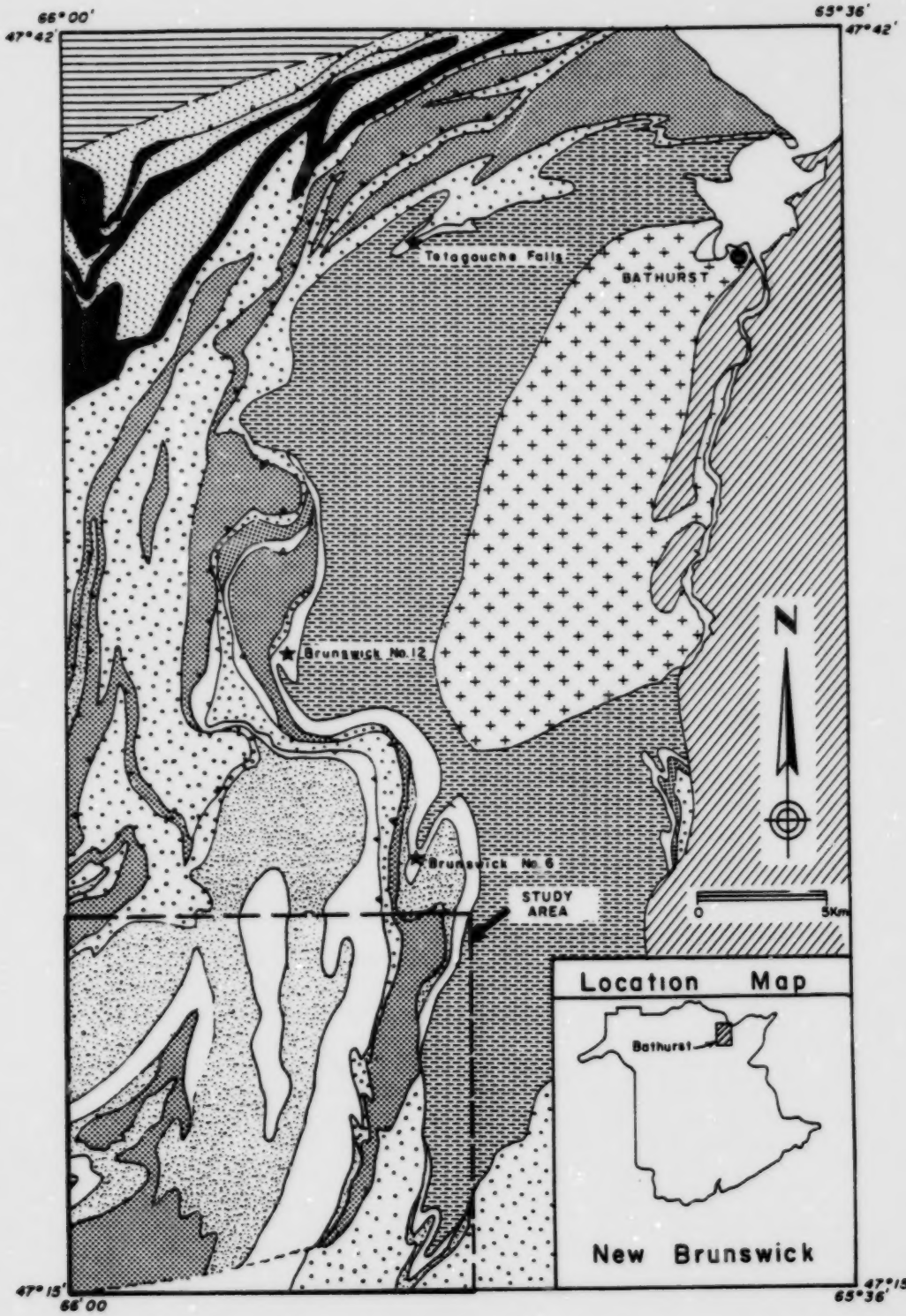


FIGURE 8. Geological map of the area around the Brunswick No. 6 and 12 deposits, Bathurst, New Brunswick (modified from van Staal 1985) showing location of the study area.

LEGEND

Carboniferous cover

DEVONIAN

Pabineau granite

SILURIAN

Chaleurs Group

ORDOVICIAN

FOURNIER GROUP

Mainly thick bedded dark grey shales and lithic/feldspathic wacke

Tholeiitic basalt

TETAGOUCHE GROUP

Mainly thin bedded, dark grey phyllitic shale and siltstone

Alkaline and tholeiitic basalt

Rhyolite (Flat Landing Brook Fm.)

Quartz-feldspar porphyry (Nepisiguit Falls Fm.)

MIRAMICHI GROUP

Mainly interbedded graphitic phyllite and quartz wacke and quartzite.

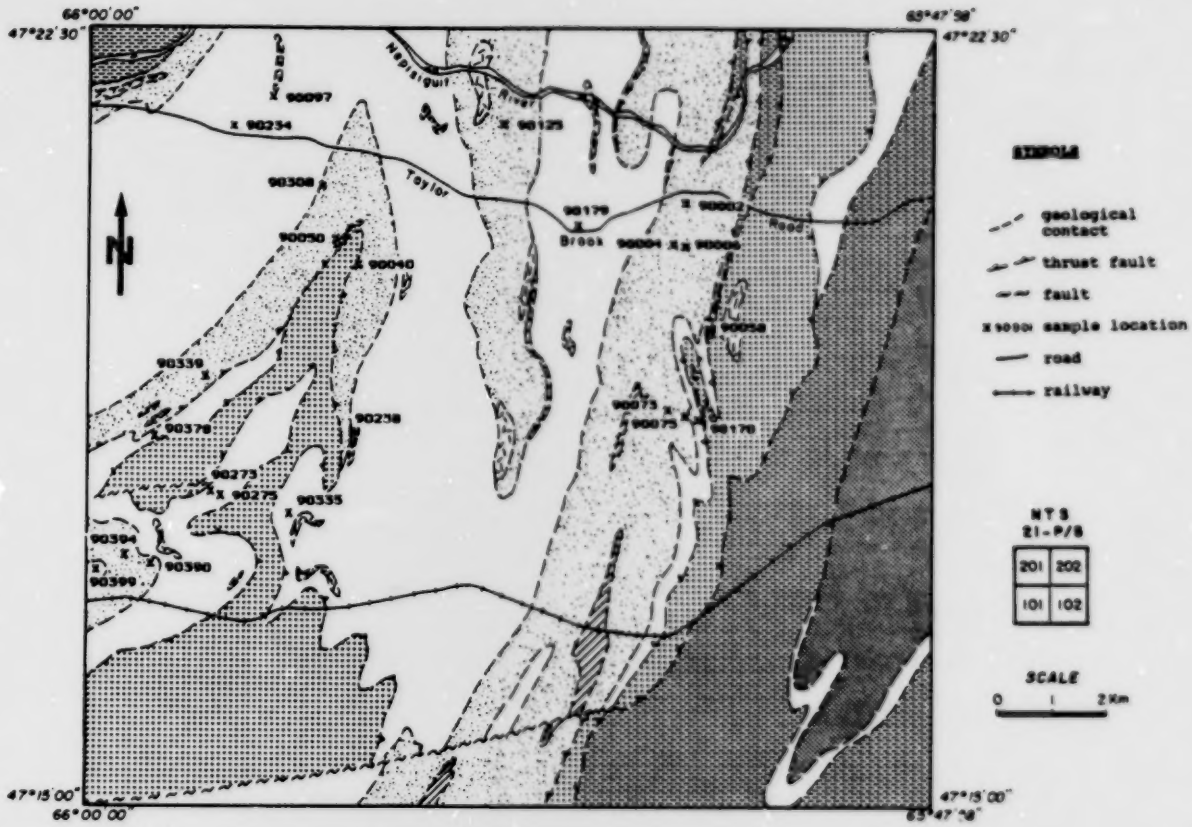
SYMBOLS

geological contact

fault

thrust fault

thrust fault; inferred



ORDOVICIAN

TETAGOUCHE GROUP

BOUCHER BROOK FORMATION:

Mainly thin-bedded dark grey and black shale and siltstone interlayered with fine-grained feldspathic sandstone and siltstone.

"Brunswick"-type alkali basalt and gabbro.

FLAT LANDING BROOK (FLB) FORMATION

Aphyric and feldspar phyric silicic volcanic rocks. Includes mainly massive to finely fragmental rhyolite, quartz and feldspar phyric rhyolite and minor sulphide mineralization.

NEPISIGUIT FALLS (NF) FORMATION

Iron formation, massive sulphide and fine-grained, greenish grey tuffaceous siltstone/shale.

Interbedded quartz and quartz-feldspar augen schist, quartz-feldspar porphyry and associated reworked pyroclastic and epiclastic rocks. Includes minor iron formation, sandstone, shale, and mafic volcanic intrusions.

MIRAMICHI GROUP

Mainly interbedded quartzite, quartz-rich sandstone, and black, dark grey and greenish grey siltstone and shale.

FIGURE 9. Geological map of the study area showing lithogeochemical sample locations (see Figure 8 for locations).

GEOLOGY

The map units shown in Figure 9 represent rocks from the Miramichi Group and the NF, FLB, and BB formations of the Tetagouche Group. The Miramichi Group rocks, which occur in the eastern part of the map area, comprise mainly fine-grained quartz-rich sandstone and quartzites interbedded with dark grey to black, graphitic siltstones and shales, that become more abundant toward the top. Overlying the Miramichi Group rocks is a thin, discontinuous horizon of NF Formation (not shown) and FLB Formation rocks. The Nepisiguit Falls Formation generally consists of pyroclastic and reworked pyroclastic rocks containing coarse-grained (2-5 mm), quartz (QAS) or quartz and feldspar (QFAS) phenocrysts (10-50%), greenish grey siltstone, and iron formation with massive sulphide. A lot of the QFAS is pyroclastic or reworked pyroclastic material, but some comprises hypabyssal quartz-feldspar porphyry (QFP) or rhyolite. Usually, the QFP has a groundmass that appears vitreous rather than granular. However, field relationships indicate that not all QFAS with vitreous groundmass is intrusive. In general, the Flat Landing Brook Formation comprises aphyric and quartz-feldspar-phyric rhyolitic rocks with associated fragmental and epiclastic rocks. When present, phenocrysts in the rhyolites are typically smaller (1-2 mm) and much less abundant (5-10%) than in the NF Formation. Furthermore, many of the so-called tuffaceous and pyroclastic rocks included in the FLB Formation are rhyolites that have undergone devitrification and fragmentation, and in some cases resedimentation. The resulting fragmental rock contains 1-5 mm sized fragments that may be misidentified as phenocrysts, crystals, or lapilli. These hyaloclastitic rocks grade into blocky "carapace" breccias and thence into massive rhyolite. Other false pyroclastic textures include nodular devitrification features that impart a pumice-rich, pseudobreccia appearance (Allen 1988). In some areas the fragmental rocks can be traced into bedded epiclastic units that are interpreted as the flanks of rhyolite domes. The BB Formation includes alkali, pillow basalt, hyaloclastites, and thin-bedded dark grey and black shale interbedded with fine-grained feldspathic sandstone and siltstone. Sedimentary rocks of the Boucher Brook (BB) Formation overlie, and are in contact with, each of the underlying formations. To the west, basalt of the BB Formation is allocthonous on the underlying rocks. The contact is marked by a high-strain zone. As the rocks above and below the basalt belong to the same formations, the rocks above the basalt must also be allocthonous. A mylonite zone at the top of the basalt is consistent with this interpretation.

Previous quarter-mile maps of the area were overcomplicated, mainly because of misidentification of hanging-wall type fragmental rhyolites, and rhyolites with false pyroclastic textures, as foot-wall type pyroclastic and epiclastic rocks (Langton and McCutcheon 1990). In order to interpret the geology, workers were required to invoke unusual stratigraphic relationships and/or complex fold patterns to explain outcrop distribution. The complex structural elements of the area were not well understood resulting in an unusual geometry of folds, the implications of which were left unexamined. Recent structural mapping of the surrounding areas (de Roo *et al.* 1990, 1991; van Staal 1985; van Staal and Williams 1984, 1986), together with detailed mapping of rock types and textures, and structural fabric analysis from the study area (Langton and McCutcheon 1990), has led to a clarification of the stratigraphy and deformation history.

The distribution of rock units in the study area reflects two generations of folds, F2 and F4, even though structural measurements indicate that there are four dominant fabric elements that can be distinguished on the basis of overprinting relationships (Figure 10). F1 folds are rare, although the S1 fabric is pervasive. This is because of transposition of the S1 fabric into the S2 orientation. The S2 fabric is best developed in the hinges of F2 folds. On the limbs, it typically forms a composite foliation with S1. The D3 features outlined in the Heath Steele area by de Roo *et al.* (1990, 1991) have not been identified in the map area, even though the Heath Steele property is less than 5 km to the west. This apparent absence of the S3 fabric may result from its flat-lying attitude, which makes it difficult to discern. The F4 folding is of a macroscopic scale and refolds F2 fold hinges along northwest axes, parallel to S4. The S5 fabric typically trends northeast and is axial planar to the macroscopic Pabineau antiform/synform pair (van Staal 1985).

CHEMISTRY

In order to further differentiate between the rocks of the Nepisiguit Falls and Flat Landing Brook formations, and to better understand the structural and stratigraphic relationships between them, 23 samples of felsic volcanic rocks from both formations were collected (see Figure 9) and chemically analysed for selected

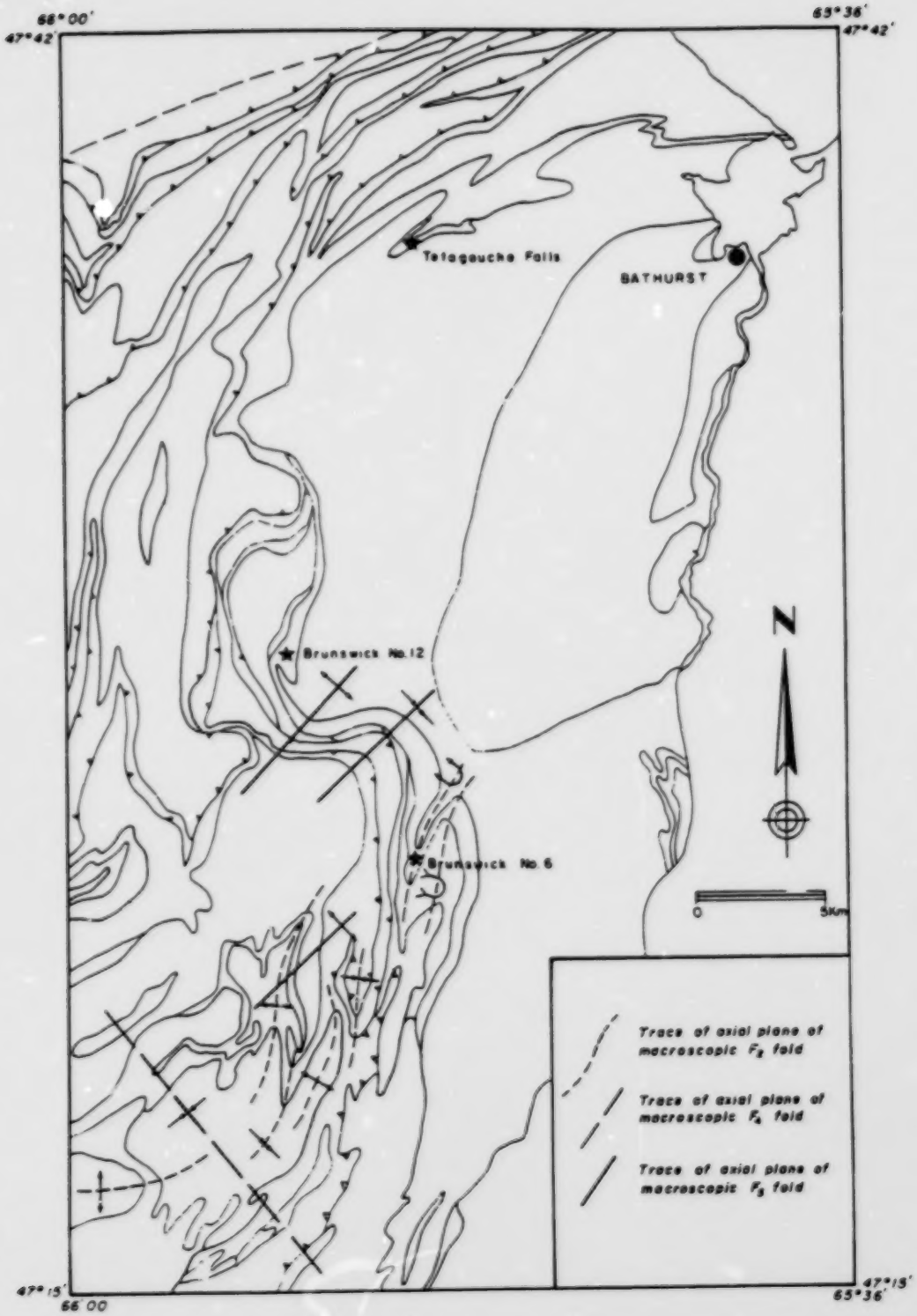


FIGURE 10. Simplified structural map illustrating axial traces of major F2, F4, and F5 folds in the vicinity of the study area (see Figure 8 for symbols).

major and trace elements. The compositions were also compared to previous data from McCutcheon (1990) and van Staal (1991).

Sample analysis was done by X-Ray Assay Ltd., Don Mills, Ontario. Samples were only taken from areas that were minimally altered and low in strain. However, the region has undergone greenschist-grade metamorphism and has a complex deformational history. For this reason high-field-strength elements (HFSE) were used for chemical comparisons, as they remain relatively immobile during seawater alteration and low-grade metamorphism.

In general, the HFSE composition of the felsic volcanic rocks from the Nepisiguit Falls and Flat Landing Brook formations is very similar and most samples plot in the rhyolite and dacite fields of the compositional discrimination diagram of Winchester and Floyd (1977) [Figure 11]. However, rare-earth element (REE) and various incompatible element concentrations reveal that some important differences exist between the two formations, specifically in the heavy-rare-earth-element (HREE) concentrations. Figures 12a and 12b show extended REE plots of, respectively, samples of QFAS/QAS (NF Formation) and rhyolite (FLB Formation). Both the rhyolites and QFAS/QAS samples have similarly shaped profiles probably indicating a genetic relationship. However, the rhyolites display distinctively elevated HREE, and slightly lower Ti concentrations compared to the QFAS/QAS samples. These trends are reflected in other sample collections obtained from similar rocks in the Bathurst Camp (Figure 13). Various element ratios were plotted on binary diagrams to distinguish between the two populations of felsic volcanic rocks. A plot of Th/Yb versus Ta/Yb, modified from Pearce (1983), best displays the separation of QFAS/QAS from rhyolite (Figure 14).

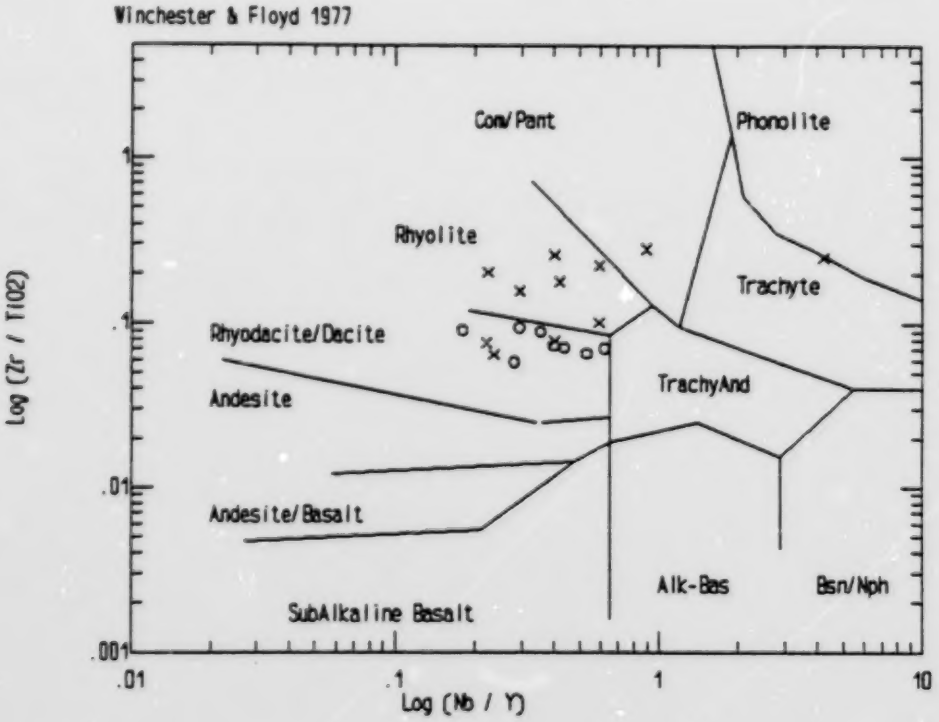


FIGURE 11. Compositional discrimination diagram (after Winchester and Floyd 1977) of QFAS/QAS (o) and rhyolite (x) samples (see Figure 9 for sample locations).

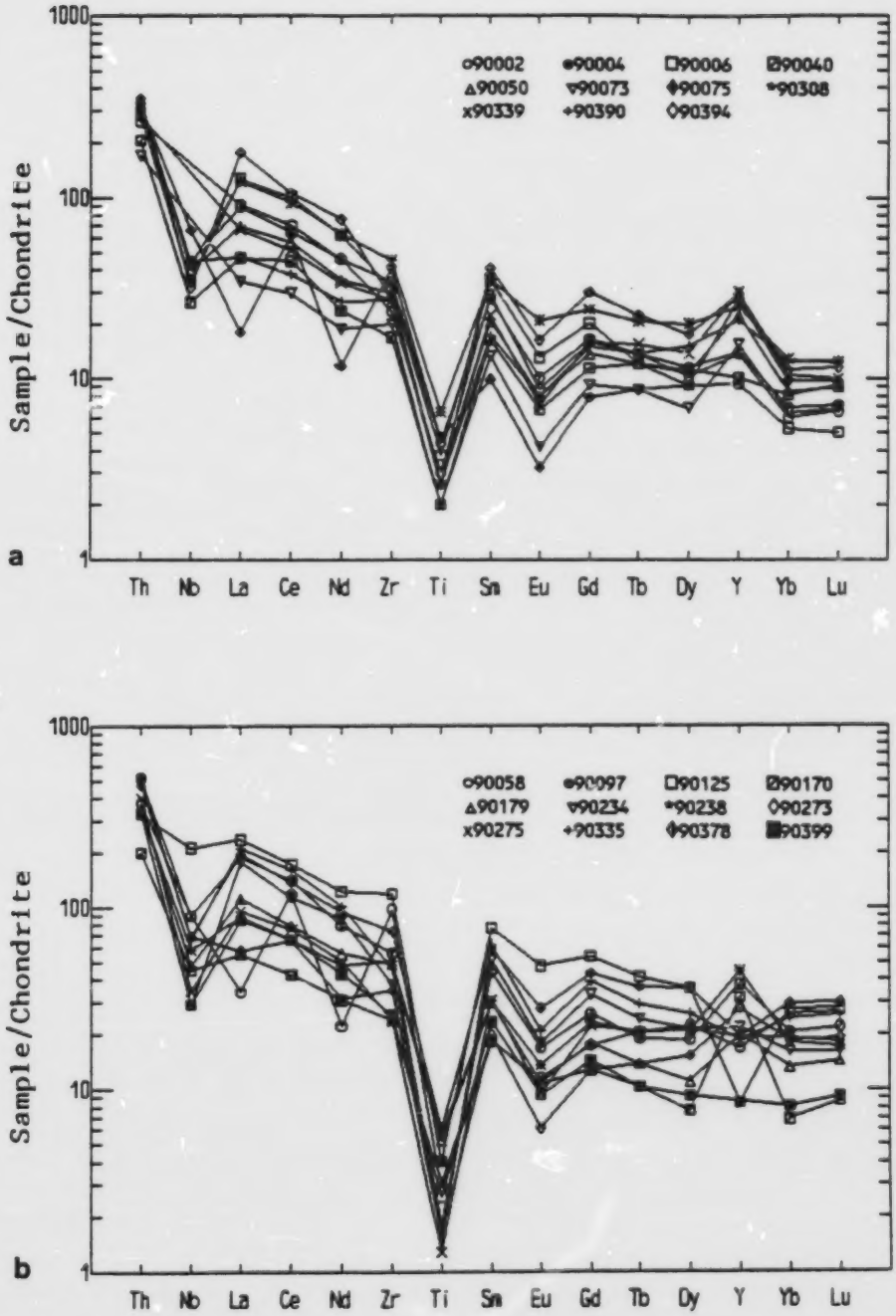


FIGURE 12. Extended rare-earth-element plots of felsic volcanic rocks from the study area. (a) QFAS/QAS (NF Fm) samples; (b) Rhyolite (FLB Fm).

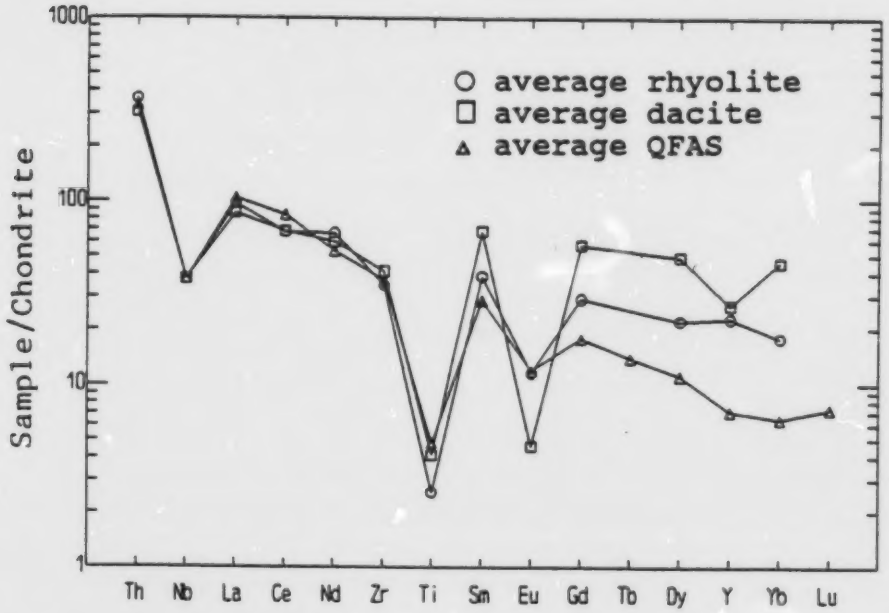


FIGURE 13. Extended rare-earth element plot of data from van Staal et al. (1991) [average rhyolite and average dacite], and McCutcheon (1990) [average QFAS].

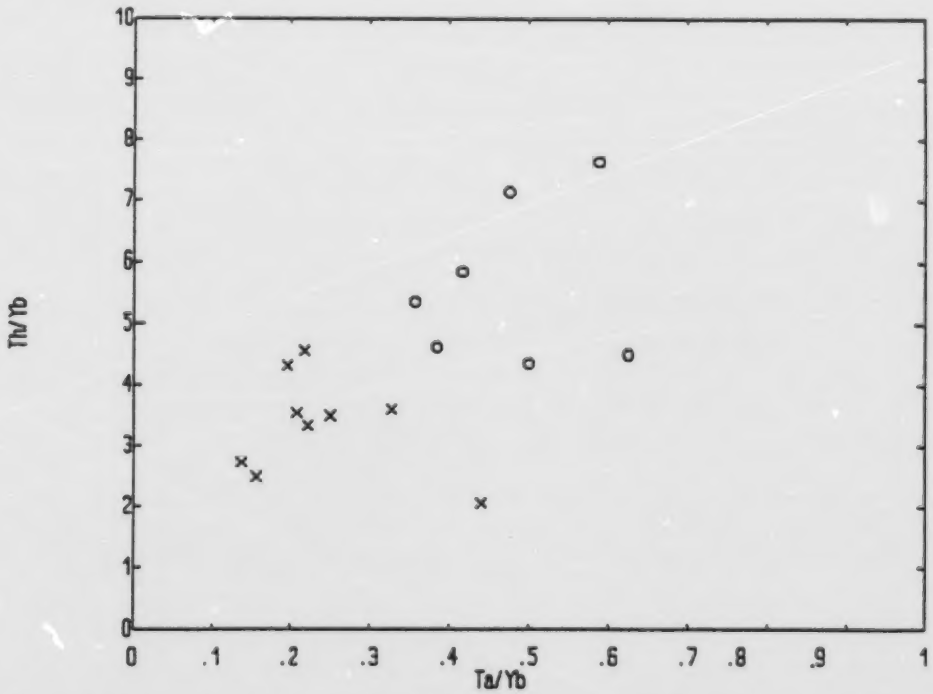


FIGURE 14. Th/Yb versus Ta/Yb diagram (modified from Pearce 1983) illustrating compositional separation of QFAS/QAS (o) from rhyolite (x) samples from the study area.

SUMMARY

1) Detailed lithologic and form-surface mapping has been completed in map areas 21 P/5 101; 102; 201; and 202 (Figure 9). Most of the area shown in Figure 9 is underlain by rocks of the Nepisiguit Falls, Flat Landing Brook, and Boucher Brook formations, which belong to the Tetagouche Group. Basalts of the Boucher Brook Formation are generally allocthonous with respect to the other two formations. The distribution of rock units indicates folding by F2 and F4 folds.

2) False pyroclastic textures are common and indicate that many of the rocks previously mapped as pyroclastics and tuffs, and included in the Nepisiguit Falls Formation, are fragmental rhyolites of the Flat Landing Brook Formation.

3) Extended REE plots of samples from the Nepisiguit Falls and Flat Landing Brook formations have similar shapes, perhaps reflecting a genetic relationship.

4) Heavy-rare-earth concentrations in the Flat Landing Brook rhyolites are characteristically higher than in the Nepisiguit Falls Formation. This is also shown by the results of other workers in the Bathurst Camp (McCutcheon 1990, van Staal *et al.* 1991). A modified Th/Yb versus Ta/Yb diagram (Pearce 1983) can be used to distinguish samples of felsic volcanic rocks from within the study area.

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ANTINOURI-NICHOLAS PROJECT, GLOUCESTER AND RESTIGOUCHE COUNTIES, NORTHERN NEW BRUNSWICK (C-NBCAMD)[15]

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During the 1991 field season, geological investigations in the project area, (NTS 21 P/12, P/13, O/9, and O/16) focused on the stratigraphy and structure of the Chaleurs Group. The group is divided into six formations comprising clastic, carbonate, and volcanic rocks, which have been traced and correlated throughout the project area. These formations are, in ascending order: Armstrong Brook (formerly New Mills in part), La Vieille (includes Limestone Point Formation), Simpsons Field, Bryant Point, LaPlante, and Free Grant (new name).

In Late Ordovician to Early Silurian time, the Elmtree and Miramichi Uplands formed as the result of closure of a back-arc basin. Chaleurs Group rocks were deposited between these uplands during the Silurian, and syndepositional deformation produced local angular unconformities and pre-cleavage folds. Penetrative deformation produced north- and east- to northeast-trending folds with axial planar cleavage. The north-trending, west-verging folds are associated with the Carl Gulch Thrust (new name) that juxtaposes volcanic and non-volcanic parts of the Chaleurs Group. Thrusting also occurred along the axes of northeast-trending folds southwest of the Elmtree Upland, *i.e.*, where the distance between the Elmtree and Miramichi Uplands is the least.

The original Rocky Brook-Millstream Fault follows the axis of a northeast-trending, doubly-plunging anticline that parallels the southern margin of the Nigadoo River Synclinorium. Ultramafic rocks exposed in the core of this anticline are interpreted to be an oceanic fragment that is underlain by Elmtree-type mélange. Rock units are repeated on opposite sides of the RBMF suggesting a minor amount of displacement along this structure.

The contact metamorphic aureoles surrounding the Antinouri Lake Granite (372 ± 4 Ma) and the Nicholas Dénys Granodiorite (381 ± 4 Ma), together with regional gravity data, indicate that the intrusions are part of a composite batholith at depth.

Au cours de la saison d'étude sur le terrain de 1991, les études géologiques menées dans la région visée (SNRC 21 P/12, P/13, O/9 et O/16) ont porté sur la stratigraphie et sur la structure du groupe Chaleurs. Le groupe est réparti en six formations comprenant des roches clastiques, carbonatées et volcaniques, qui ont été décelées et comparées dans toute la région étudiée. Ces formations sont, dans un ordre ascendant : le ruisseau Armstrong (précédemment en partie New Mills), La Vieille (comprenant la formation de Limestone Point), Simpsons Field, Bryant Point, LaPlante et Free Grant.

À l'époque de l'Ordovicien supérieur au Silurien inférieur, les hautes terres d'Elmtree et de Miramichi ont été formées par suite de la fermeture du bassin arrière-arc. Les roches du groupe Chaleurs ont été déposées dans ces hautes terres au cours du Silurien, et la déformation synsédimentaire a entraîné des discontinuités angulaires locales et des plis de pré-schistosité. La déformation pénétrante a produit des plis en direction nord et est à nord-est accompagnés d'une schistosité axiale planaire. Les plis en direction nord et descendant vers l'ouest sont associés à la poussée de Carl Gulch (nouveau nom), qui côtoie les parties volcaniques et non volcaniques du groupe Chaleurs. Une poussée s'est également manifestée le long des axes des plis dirigés vers le nord au sud-ouest des hautes terres d'Elmtree, c.-à-d. à l'endroit où la distance entre les hautes terres d'Elmtree et de Miramichi est la plus réduite.

La faille de Rocky Brook-Millstream (FRBM) suit l'axe de l'anticlinal double plongeant en direction nord-est, qui est parallèle au bord sud du synclinorium de la rivière Nigadoo (SRN). Les roches ultramafiques exposées dans le noyau de cet anticlinal sont interprétées comme un fragment océanique dont la base repose sur un mélange de type Elmtree. Des unités lithologiques se répètent sur les bords opposés de la FRBM, révélant ainsi un léger déplacement le long cette structure.

Les auréoles métamorphiques entourant le granit du lac Antinouri (372 ± 4 Ma) et la granodiorite de Nicholas-Denys (381 ± 4 Ma), ainsi que les données gravimétriques régionales, indiquent que les intrusions font partie intégrante d'un batholite composite en profondeur.

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[15]Contribution to the Canada - New Brunswick Cooperation Agreement on Mineral Development, 1990-95. Project carried by the Geological Surveys Branch of the New Brunswick Department of Natural Resources and Energy. This project is meant to update the geology and mineral-deposit inventory of an area that has been prospected since the early 1800's. The results will give a much better understanding of the three-dimensional geology and will help exploration geologists formulate strategies for finding new deposits of zinc, lead, silver, gold, and other metals.

INTRODUCTION

The Antinouri-Nicholas project (C-NBCAMD) comprises four 1:20 000-scale map areas in addition to parts of seven others (Figure 15) and encompasses the Antinouri Lake, Nicholas Dénys, and Nigadoo intrusions. These intrusions appear to be part of a largely blind intrusive suite as shown by the regional Bouguer gravity contours (Figure 15). The first phase of this project includes geological mapping as reported by McCutcheon (this volume). Initial results were described by Walker and McCutcheon (1989) and Walker *et al.* (1990); the results of this year's mapping are described below. Figure 16 shows the simplified geology of the 1:20 000 map areas that have been completed to date and Figure 17 shows schematic stratigraphic columns from various parts of the area.

MAP UNITS

A polydeformed triangular shaped inlier of Ordovician rock, referred to as the Elmtree Upland (Fournier Group and Elmtree Formation), is exposed in the east-central part of the project area (Figure 18). A large east-north-east-trending trough referred to as the Nigadoo River Synclinorium (NRS), formerly the Nigadoo River Syncline of Skinner (1974), contains Chaleurs Group sedimentary rocks and separates the Elmtree Upland from the Miramichi Upland to the south (Figure 18). Stratigraphic relationships within this synclinorium are illustrated in cross-section A-A' (Figure 19). Similar Chaleurs Group rocks can be found on the north side of the Elmtree Upland. A north-south-trending belt of Siluro-Devonian volcanic and sedimentary rocks borders the Elmtree Upland to the west.

Twelve units are shown on the small-scale geological map (Figure 16) and are described in ascending stratigraphic order below. A few outliers of flat-lying, Carboniferous conglomerate (Bathurst Formation) also occur in the map area, but are too small to show in Figure 16.

ORDOVICIAN:

Unit Od, the Devereaux Formation, constitutes the lower part of the Fournier Group. It consist. gabbros, sheeted dykes, and MORB-like primitive tholeiitic basalts and is considered to be an ophiolite fragment that has been thrust over Unit Op (Langton and van Staal 1989).

Unit Op, the Pointe Verte Formation, constitutes the upper part of the Fournier Group and consists of alkali basalts (Opv) and interbedded slates and greywackes (Ops). A medium-grained conglomerate containing well-rounded clasts of quartz, siltstone, gabbro, and volcanic rocks has been delineated within the Point Verte Formation. The source of this conglomerate was apparently the uplifted Devereaux thrust sheet.

Unit Oe encompasses rocks of the former Elmtree Group, now Elmtree Formation (Langton and van Staal 1989). This unit is divisible into two parts: autochthonous slates, quartz wackes, and basalts (Oe); and tectonic mélange (Oem). The mélange, which contains sedimentary, mafic, and ultramafic fragments in a black slate matrix, outcrops in a wide zone adjacent to the Fournier Group and in a northeast-trending zone southeast of the Antinouri Lake Granite (Figure 16). The outcrop distribution of this mélange defines a regional fold referred to as the Black Point Antiform and indicates that the Fournier Group was once more extensive than presently mapped. Similar mélange occurs locally south of the Rocky Brook-Millstream Fault (RBMF) in Unit Ou.

Unit Ou contains quartzo-feldspathic grit of the Millstream Formation (van Staal *et al.* 1988) , graphitic slate, minor mélange (similar to Unit Oem) and, in the southwest part of the map area, mafic volcanic rocks of the Fournier and Tetagouche groups.

SILURIAN:

Unit Sa includes the Armstrong Brook and the overlying La Vieille formations. Although mappable at 1:20 000 scale, these formations have been grouped together on the small-scale map (Figure 16). Along the RBMF, Unit Sa also contains Ordovician(?) ultramafic rocks that unconformably underlie the Armstrong Brook Formation in the core of an anticline. Although the lower contact of these ultramafic rocks has not been observed, it is interpreted to be a thrust because there is Elmtree-type mélange farther south.

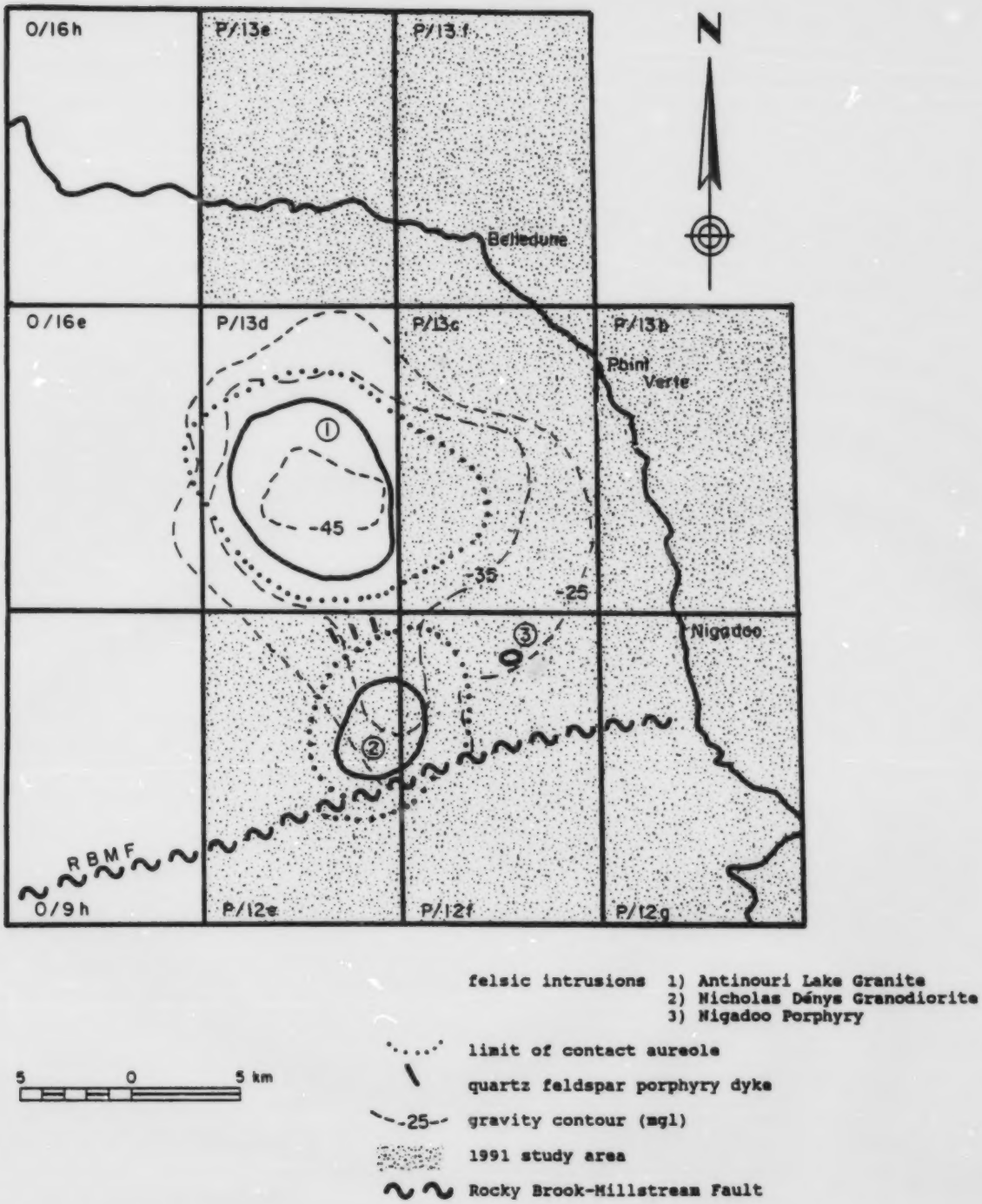


FIGURE 15. Antinouri-Nicholas project index map. The contact aureole of the Nicholas Dénys and Antinouri Lake intrusions and the -25, -35, -45 mgal regional Bouguer gravity contours are also shown. Note the close correspondence between the limits of the aureole and the -25 mgal contour.

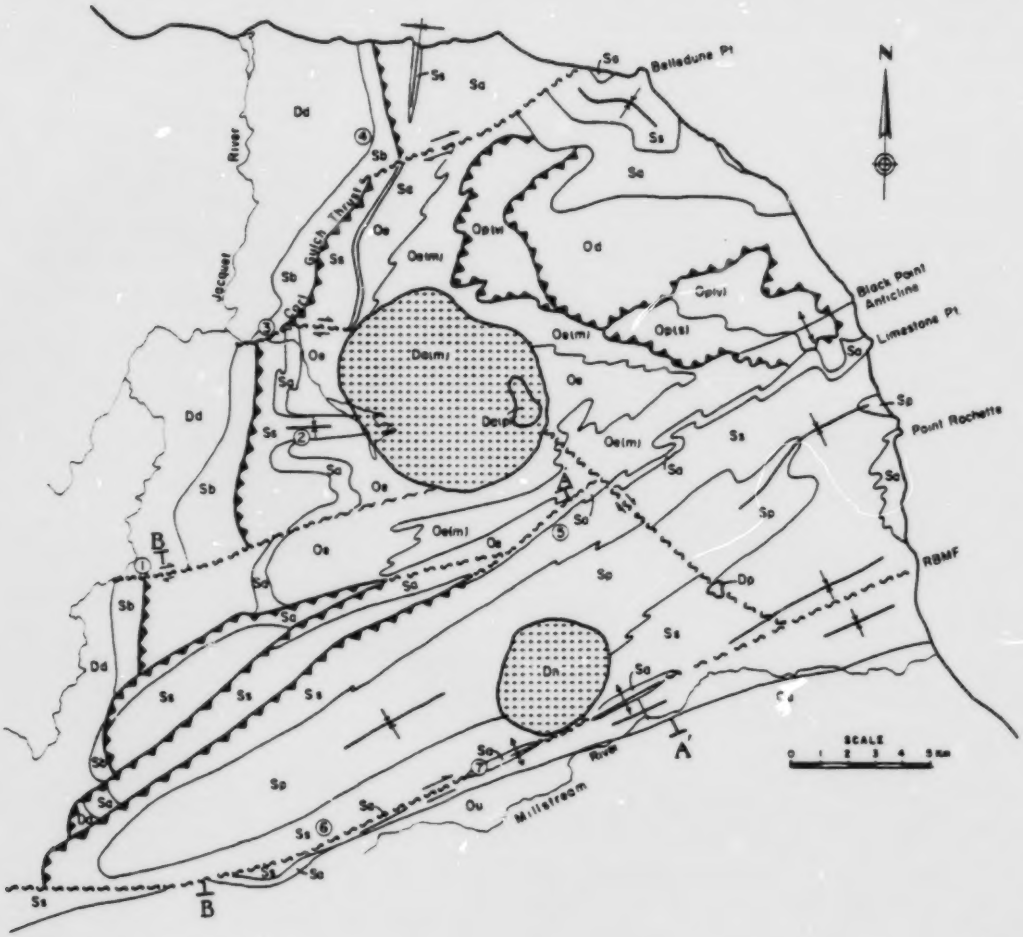


FIGURE 16. Simplified geology of the Antinouri-Nicholas project area.

The Armstrong Brook Formation (Noble 1976) consists of red to grey pebble to cobble conglomerates (locally with volcanogenic matrix) grits, and sandstones, and generally constitutes the base of the Silurian section. At the type section in the northern part of the map area, the conglomerates contain abundant, commonly well-rounded, clasts of mafic and felsic volcanic rocks, jasper, green chert, and other sedimentary fragments. A mafic volcanic flow is found near the base of the type section, and minor limestone occurs near the top of the section.

The Armstrong Brook Formation contains coarse-grained volcanic clasts adjacent to the volcanic parts of the Miramichi and Elmtree uplands, *i.e.*, in the southwest part of the map area and to the east, respectively (Figures 15 and 16). Elsewhere, where the uplands consist primarily of sedimentary rocks, this unit is dominated by greywacke and granule conglomerate, with quartz being the dominant constituent. Altered clasts that appear to be ultramafic in nature were found in the conglomerate where it overlies ultramafic rocks exposed along the RBMF.

The Llandovery C6 - Wenlock, La Vieille Formation overlies the Armstrong Brook Formation and consists of nodular to massive limestones, calcarenites, and calcareous siltstones (Noble 1976). The Limestone Point Formation (Noble 1976) is included in this map unit because it cannot be distinguished from the La Vieille

LEGEND

DEVONIAN

Felsic Intrusions

Dp	Nigadoo porphyry	
Da	Antinouri Lake Granite,	Da(p) porphyritic phase Da(m) medium-grained phase
Dn	Nicholas Dénys Granodiorite	

DALHOUSIE GROUP

Dd	Undivided sedimentary, mafic and felsic volcanic rocks	

SILURIAN

CHALEURS GROUP

Sp	Free Grant Formation	Sb	Bryant Point Formation
Ss	LaPlante Formation Simpsons Field Formation	Sa	La Vieille Formation Armstrong Brook Formation

ORDOVICIAN

TETAGOUCHE GROUP

Oe	Elmtree Formation	Oe(m) mélange	Ou	undivided

FOURNIER GROUP

Od	Devereaux Formation	
Op	Pointe Verte Formation	Op(s) sediments Op(v) volcanics

SYMBOLS

	fault (strike-slip with sense of movement, thrust)
RBMF	Rocky Brook-Millstream Fault
	syncline
NRS	Nigadoo River Syncline
	anticline

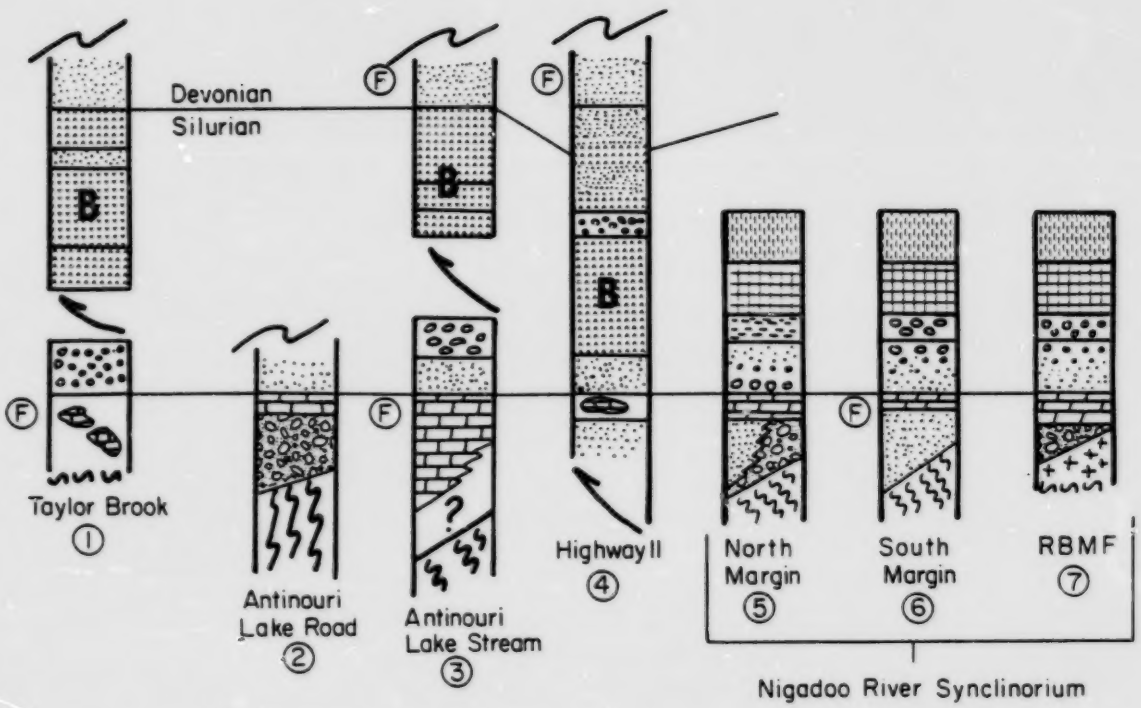


FIGURE 17. Schematic stratigraphic columns from various parts of the Antinouri-Nicholas area. The location of each column is shown in Figure 18.

limestones away from the type section. Locally, the La Vieille Formation constitutes the apparent base of the Silurian section.

The La Vieille Formation exhibits rapid thickness and facies changes along strike. A new fossil locality in thin limestone and calcareous siltstone was found near the southern margin of the NRS by C.R. van Staal. This locality, (GSC # O-104382), yielded a Silurian (possibly Llandovery) fauna suggesting that these rocks are correlative with the La Vieille Formation.

Unit Ss includes the Simpsons Field and LaPlante formations. At the type section, the Simpsons Field Formation (Walker and McCutcheon 1990) is divisible into a lower unit of grey to black sandstone and siltstone that is locally calcareous and an upper unit of magnetic, polymictic pebble conglomerate. The conglomerate predominantly contains clasts of mafic volcanic rocks with minor clasts of chert, quartz, jasper, and slate. This unit can be traced along strike to the southwestern part of the map area, *i.e.*, the southern margin of the NRS. Adjacent to, and north of the RBMF, the Simpsons Field Formation is also divisible into two parts: a lower unit composed of micaceous fine-grained sandstone and siltstone at the base, which coarsens upward into coarse-grained feldspathic wacke and granule conglomerate; and an upper unit of red to grey polymictic conglomerate that produces a positive magnetic anomaly. Along the northern margin of the NRS, the Simpsons Field Formation consists of non-magnetic conglomerates that fine upward into non-calcareous red and green slate with an elevated magnetic signature. These conglomerates were formerly assigned to the Armstrong Brook Formation.

Conglomerates in the northern and western parts of the map area, which were previously assigned to the New Mills Formation, are now included in the Simpsons Field Formation. The New Mills Formation, as defined by Greiner 1967, lies within a dominantly volcanic sequence. This volcanic sequence is restricted to the area west of a major fault, the Carl Gulch Thrust (Figure 16). In contrast, the Simpsons Field Formation is

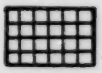
DEVONIAN

DALHOUSIE GROUP

SILURIAN

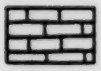
CHALEURS GROUP

Free Grant Formation


LaPlante Formation

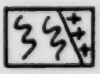
Simpsons Field Formation

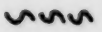
Bryant Point Formation
volcanic/ sedimentary


La Vieille Formation

Armstrong Brook Formation

ORDOVICIAN


Elmtree Formation
mélange or slate / ultramafic


fault

fossil

thrust fault

Legend for Figure 17.

within a dominantly clastic sequence east of this thrust. Both formations postdate La Vieille rocks and may be synchronous, but this cannot be proven because they are in contact with different rock units.

The Pridolian LaPlante Formation, formerly the Laplante unit of the Petit Rocher Formation (Noble 1985), comprising limestone and calcareous, fossiliferous slates, overlies the Simpsons Field Formation in the NRS. This unit has been elevated to formation status because it constitutes a mappable unit that can be traced inland as far west as Simpsons Field in the Upsalquitch Forks map area (Walker and McCutcheon 1990). Near the coast, the limestone is massive to nodular and varies from grey to buff in colour. Fossils, particularly large tabulate corals, are abundant and soft-sediment deformation structures are common. In general, the proportion of limestone decreases inland where the unit consists of fossiliferous calcareous slates with minor limestone interbeds. However, limestone is abundant at the western end of the NRS adjacent to the RBMF.

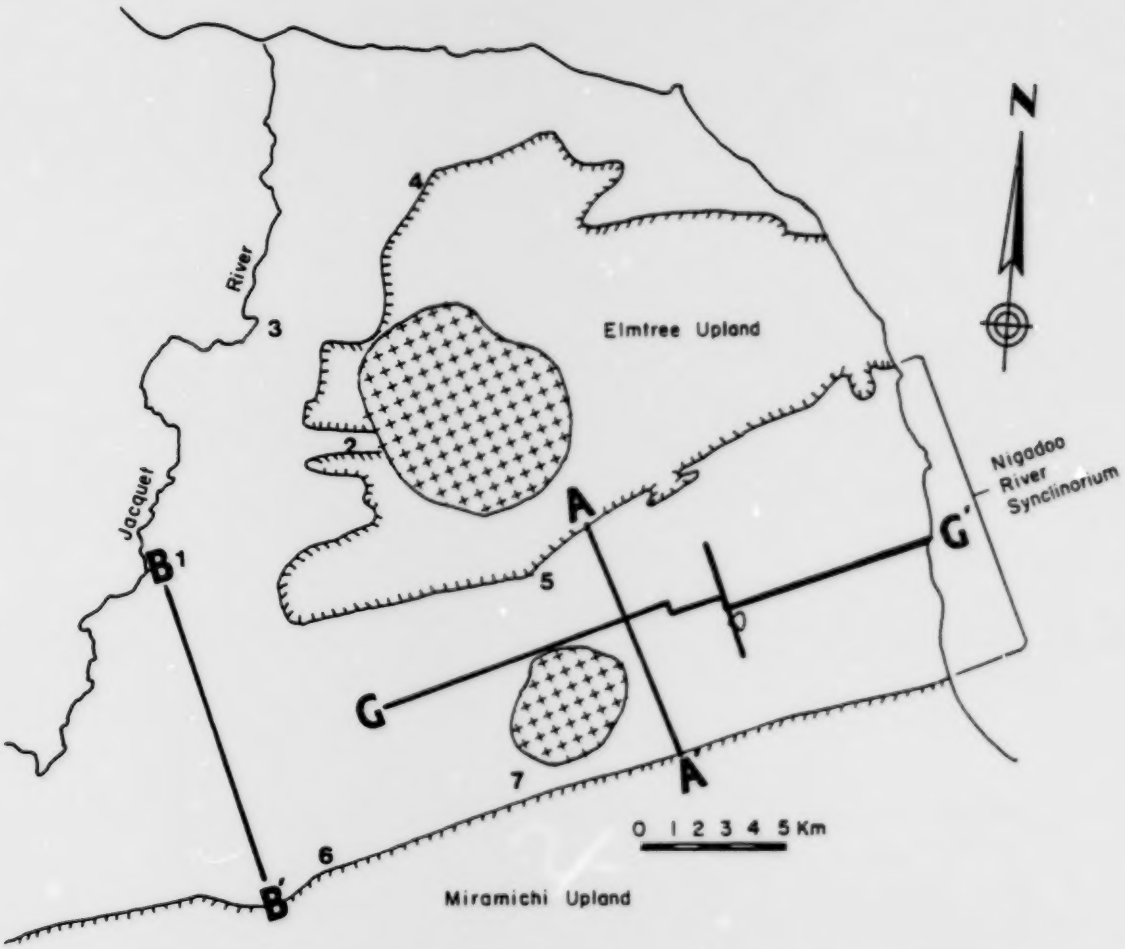


FIGURE 18. Location map for stratigraphic columns, cross sections, and gravity profile.

Unit Sb consists of mafic and minor felsic volcanic rocks that are assigned to the Bryant Point Formation. At the type locality, the Bryant Point overlies La Vieille Limestone and underlies Devonian rocks of the Dalhousie Group. This unit is found west of the Carl Gulch Thrust. At least some of these rocks are laterally equivalent to the Simpsons Field Formation, parts of which contain abundant volcanic material.

Unit Sp constitutes the Free Grant Formation, a newly defined unit that is characterized by thin-bedded, ripple-laminated, calcareous, fine-grained sandstone and greenish grey siltstone, with minor green and red slate. These rocks conformably overlie the LaPlante Formation and were formerly included in the Petit Rocher Formation, a unit that should be abandoned because it includes rocks of the La Vieille and Simpsons Field formations.

DEVONIAN:

Unit Dd consists of undivided sedimentary and volcanic rocks that belong to the Devonian Dalhousie Group. This unit is in conformable and gradational contact with Chaleurs Group rocks in the western part of the map area. The contact between the two groups is tentatively drawn at the last occurrence of red beds within the volcanic pile.

INTRUSIONS:

Three of the twelve map units (Figure 16) constitute intrusive rocks. As well, there are a number of felsic and mafic dykes that cut Siluro-Devonian rocks, but are too small to show on Figure 16.

Unit Dn, the Nicholas Dénys Granodiorite, is pinkish grey, medium-grained equigranular to subporphyritic granodiorite. Radiometric dating by U-Pb method gave an age of 381 ± 4 Ma (M. Bevier, written communication, 1991 and Figure 20a). The mappable contact aureole (hornfels) associated with this intrusion extends 1.5 km from the surface contact, except in the northeast where it extends up to 2.5 km from the contact.

Unit Da the Antinouri Lake Granite is divisible into two phases: Unit Da(m) is a pink, medium-grained, equigranular biotite granite; Unit Da(p) is a quartz-feldspar porphyritic granite that intrudes the medium-grained phase and has a positive magnetic anomaly. U-Pb radiometric dating of the medium-grained granite yielded an age of 372 ± 4 Ma (M. Bevier, written communication, 1991 and Figure 20b). The mappable contact aureole associated with this intrusion extends about 1.5 km from the surface contact except in the east, where the aureole is up to 4 km from the contact.

Unit Dp is the quartz-feldspar porphyry that is genetically related to the Nigadoo base-metal deposit. Lithologically similar porphyry dykes (not shown on Figure 16) occur in the area between this unit and the other intrusions. The quartz-feldspar porphyritic phase of the Antinouri Lake Granite may be coeval with the Nigadoo Porphyry. Both intrusions appear to have been emplaced along the same northwest-trending fault (Figure 16).

In conclusion, the observations on the three units above, combined with the Bouguer gravity contours (Figure 15), suggest that these intrusions are part of an intrusive suite, with a roof that dips shallowly to the east.

GRAVITY SURVEY

A gravity survey conducted over the central part of the Nigadoo River Synclinorium was contracted to Northeast Exploration Services Ltd. of Bathurst. The survey consisted of a single line that followed roads and power lines from the coast north of Nigadoo westward to Massabielle (Figure 18). The purposes of this survey were to determine if the Nigadoo Porphyry has a gravity signature and to obtain a gravity profile across the largely concealed intrusive suite. The data were collected at 100-m intervals along a total line length of 25.1 km.

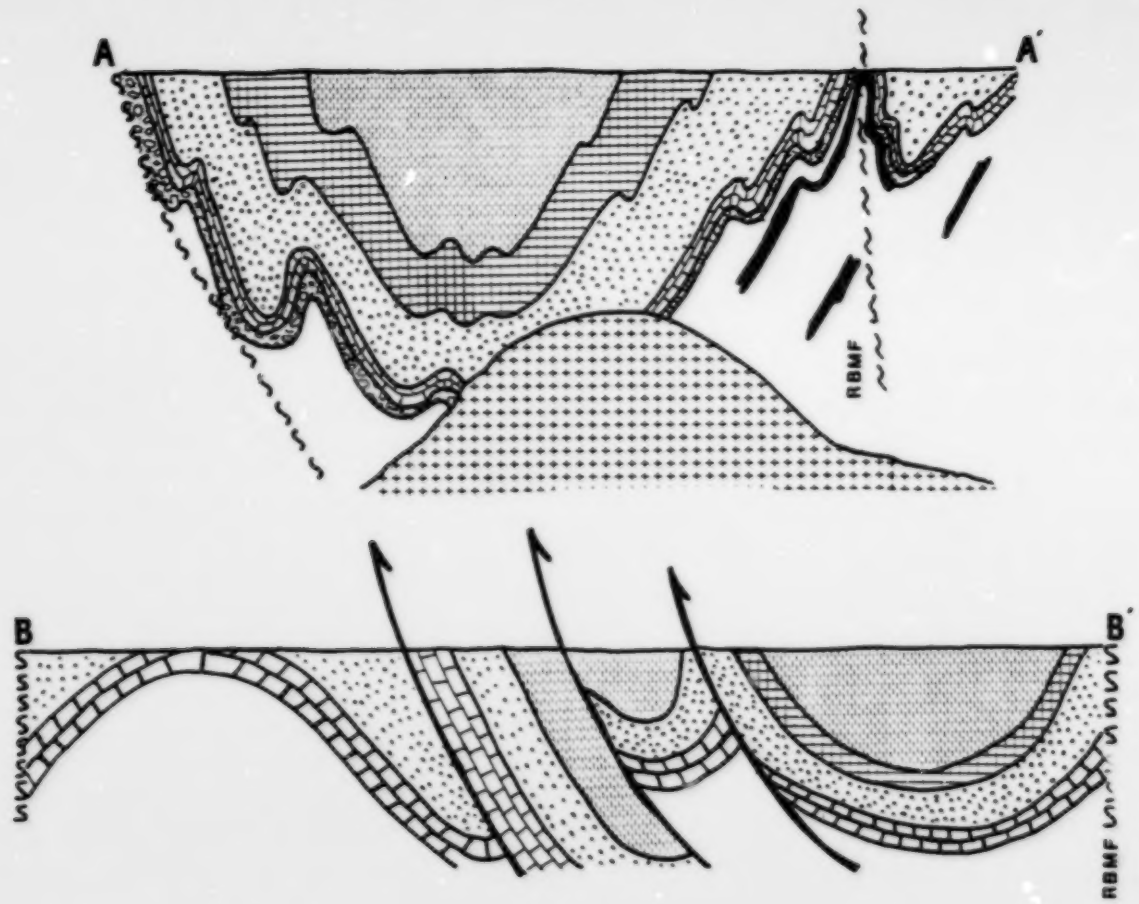
The gravity survey detected both the Nigadoo Porphyry and the Nicholas Dénys Granodiorite north of its surface exposure (Figure 21). The gravity profile also shows a positive anomaly near the coast. One possible explanation for this anomaly is Fournier Group mafic rocks beneath a thin Silurian sedimentary cover.

TECTONIC SETTING

Closure of a back-arc basin in Late Ordovician to Early Silurian time produced southward-verging thrusts that resulted in the development of an imbricate thrust stack (Langton and van Staal 1989) and the formation of the Elmtree and Miramichi uplands (Figure 18). Within the Elmtree Upland, the uppermost nappe constitutes ophiolitic rocks of the Devereaux Formation; the lower nappe comprises volcanic and sedimentary rocks of the Pointe Verte Formation. The basal nappe overlies mélange of the Elmtree Formation. Large thrust slices of mafic and ultramafic rocks occur within this mélange including the peridotite exposed along the RBMF.

Following formation of the Elmtree and Miramichi uplands, a Lower to Upper Silurian clastic,volcanic, and carbonate sequence was deposited. Deformation and deposition were coeval as evidenced by pre-cleavage folds and an angular unconformity at the top of the La Vieille Formation.

Ultimately, penetrative deformation produced east- to northeast-trending double-plunging folds with axial planar cleavage throughout most of the area, *i.e.*, the NRS and the small unnamed syncline west of Antinouri Lake. However, there are north-trending folds that are overturned to the west in the western part of the map area. This deformation also produced west- and northwest-verging thrusts in the west and southwest parts of the map area, respectively. The west-verging thrust front, the Carl Gulch Thrust, marks the eastern limit of north-trending, overturned folds and also marks the eastern edge of the Siluro-Devonian volcanic field. The thrust front is offset along a series of east-west-trending dextral strike-slip faults that are believed to be coincident with thrusting. The northwest-verging thrusts developed at northeast-trending fold hinges as compression continued, and are localized in the area where the distance between the Elmtree and Miramichi



SILURIAN

CHALEURS GROUP

Free Grant Formation

LaPlante Formation

Simpsons Field Formation

La Vieille Formation

Armstrong Brook Formation

DEVONIAN

felsic intrusion

ORDOVICIAN

Elmtree Formation

ultramafic raft

fault

FIGURE 19. Schematic cross sections of the Nigadoo River synclinorium. The location of each cross section is shown on Figures 16 and 18.

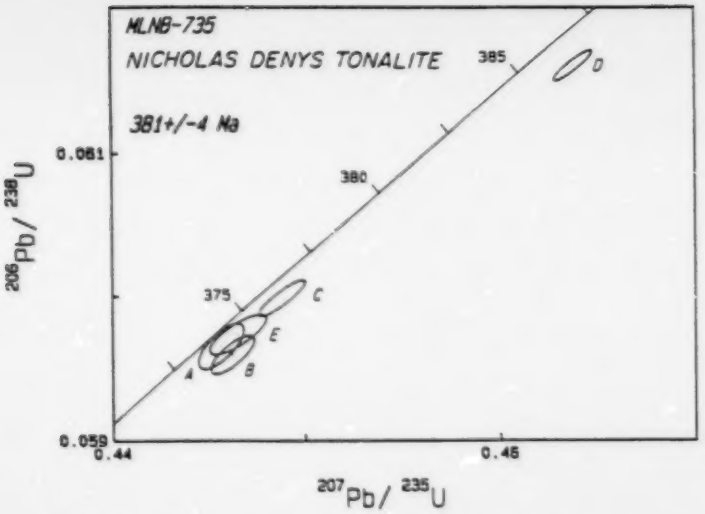


FIGURE 20a. Isochron for the Nicholas Dénys Granodiorite (tonalite).

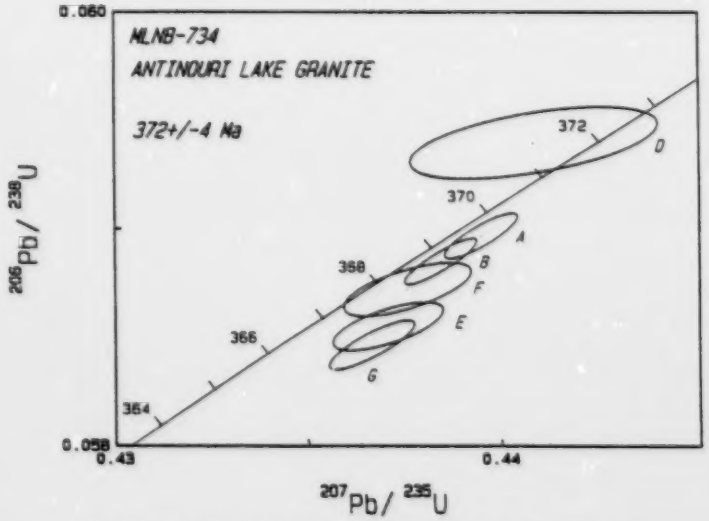


FIGURE 20b. Isochron for the Antinouri Lake Granite.

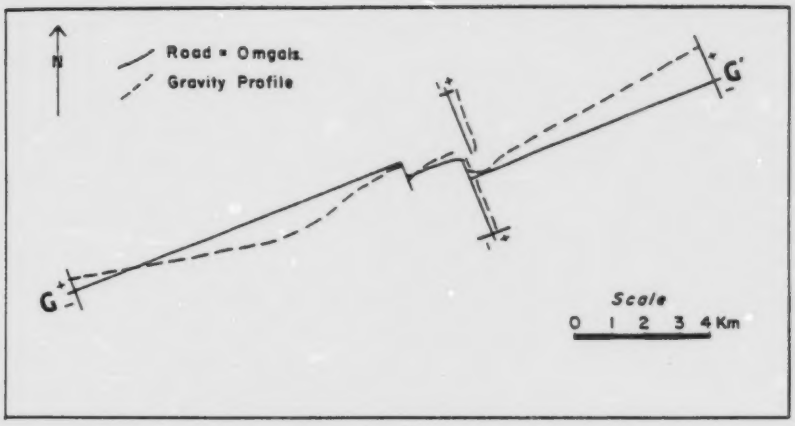


FIGURE 21. Bouguer gravity profile. See Figure 18 for location.

uplands is the shortest (21 O/9h). Cross-section B-B' (Figure 19), illustrates the structural relationships in this area.

The RBMF is a dextral strike-slip fault considered to have substantial offset (van Staal and Fyffe 1991). The main branch of this fault (Main Break of Skinner 1974) follows the axis of a parasitic double-plunging anticline near the southern margin of the NRS. The same stratigraphic succession, *i.e.*, ultramafic rocks unconformably overlain by conglomerate and limestone, occurs on both sides of the fault trace. This leads us to believe that there is a relatively small amount of post-Silurian movement along this fault. Furthermore, the contact aureole of the Nicholas Dénys Granodiorite is offset by less than 600 m.

MINERALIZATION

Mineral occurrences within the Antinouri-Nicholas project area have been divided into thirteen categories (see Gardiner, this volume). All but five of these are associated with the intrusive suite. The distribution of intrusion-related occurrences is governed by a combination of factors, particularly the juxtaposition of favourable stratigraphic and/or structural traps with the contact aureoles of the different intrusions.

Favourable stratigraphic traps are limestone and ultramafic units within contact aureoles. The La Vieille limestone has been metamorphosed to magnetite skarn and porcelanite and is the host for several (29) base-metal occurrences. Ordovician limestone of the Elmtree Formation hosts five skarn-type occurrences, all of which are within the aureole of the Antinouri Lake Granite. The LaPlante Formation intersects the contact aureole of the Nicholas Dénys Granodiorite and has potential for skarn-type mineralization, although this target has received little exploration to date. Nickel occurrences are spatially associated with ultramafic blocks or sheets in the Elmtree mélange. These occurrences are predominantly within the contact aureole of the Antinouri Lake Granite.

There are two sets of subvertical faults that are favourable structural traps for mineralization. The most significant trends from 130 to 150 degrees. Most vein-type occurrences are associated with this trend. The other trends about 70 degrees. Occurrences related to this set are most abundant south of the RBMF.

In addition to the favourable stratigraphic and/ or structural traps, there appears to be a metal zonation associated with the contact aureoles. For example, around the Nicholas Dénys Granodiorite, Mo-Cu occurs within the granite, and W and minor Mo are immediately adjacent to the granite; base metals are concentrated within the contact aureole and most As/Au vein mineralization is just outside the contact aureole.

CONCLUSIONS

Highlights of the 1991 field season are as follows:

1. The RBMF follows the axis of an east-northeast-trending double-plunging anticline. Peridotite, apparently an ocean-floor fragment that is underlain by Elmtree-type mélange, occurs in the core of this anticline and is unconformably overlain by Chaleurs Group rocks. Stratigraphy can be correlated on both sides of the fault indicating that there is a minor amount of movement along this structure.

2. Along the southern margin of the NRS, micaceous fine-grained sandstone and siltstone of the Simpsons Field Formation unconformably overlie Elmtree-type mélange. Locally, the contact between Ordovician and Silurian rocks is faulted, but nowhere is the contact found to be gradational. Similar contact relationships exist along the southern margin of the Elmtree Upland.

3. Grits of the Ordovician Millstream Formation (van Staal *et al.* 1988) can be distinguished from Silurian greywackes by thick beds (commonly >1 m), the presence of two cleavages, and abundant feldspar and volcanogenic quartz in the former unit.

4. The Chaleurs Group has been divided into six units that have been traced and correlated along all three margins of the Elmtree Inlier. They are, in ascending order: Armstrong Brook, La Vieille, Simpsons Field, Bryant Point, LaPlante, and Free Grant (new name) formations. The Petit Rocher Formation should be abandoned because it includes rocks of the La Vieille and Simpsons Field formations.

5. Faults in the southwestern part of the map area, which were previously considered to be dextral strike-slip faults, are now interpreted to have a thrust component. Similarly, a major north-trending thrust, the Carl Gulch Thrust, has been identified.

6. Radiometric dating (U-Pb) of the Antinouri Lake Granite and the Nicholas Dénys Granodiorite yielded ages of 372 ± 4 Ma and 381 ± 4 Ma, respectively.

7. The metamorphic aureoles surrounding the Devonian plutons have been delineated and indicate that the intrusions dip shallowly to the east.

8. Gravity surveys can be used as a tool for locating blind felsic intrusions the size of the Nigadoo Porphyry.

9. The Elmtree mélange is more extensive than previously recognized within the Elmtree Inlier. Notably, Elmtree-type mélange exists south of the RBMF.

10. The Free Grant Formation is a fine-grained clastic unit that overlies the LaPlante Formation.

11. Conglomerates found east of the Carl Gulch Thrust, where there are virtually no volcanic rocks, are considered part of the Simpsons Field Formation rather than the New Mills Formation. The Simpsons Field Formation is thought to occupy the same stratigraphic level as the volcanic units west of the thrust boundary because it contains abundant volcanic detritus.

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SURFICIAL GEOLOGY AND TILL GEOCHEMISTRY OF THE CALIFORNIA LAKE MAP AREA (NTS 21 O/8); GLOUCESTER, NORTHUMBERLAND, AND RESTIGOUCHE COUNTIES; NEW BRUNSWICK (C-NBCAMD)[16]

M.A. Parkhill
Project Geologist

Mapping and sampling of surficial materials at a scale of 1:50 000 has been completed in the California Lake map area (NTS 21 O/8). B-horizon soil, basal till, and pebbles were sampled at 266 sites on a 2 km grid. Soil profile descriptions and vegetation inventories were prepared. Tills will be analysed for Au plus 33 elements, and selected base metals. Detailed mapping and collection of 37 basal till samples for geochemical analysis, was completed around the Halfmile Lake mineral deposit. A total of 72 basal till samples were collected for Noranda Technology Center for geotechnical testing.

Recording of 700 striae, as well as groove and roche moutonnée locations, indicate an early eastward ice movement followed by northeastward- and southeastward-flowing ice. Minor late-stage, local ice flows in various directions followed throughout the area. Till fabrics reflect a gradual shift in ice movement from eastward through to southeastward. Granite-boulder erratics, mainly from the Mount Elizabeth Intrusive Complex, indicate glacial transport of up to 30 km in an east-northeast direction.

Most of the area is covered by a thin layer of Late Wisconsinan basal till (1-2 m) that can be subdivided into three units based on texture, composition, topography, underlying bedrock, and the presence or absence of an overlying layer of colluvium. Till is sandy over granite bedrock where a layer of preglacial weathered bedrock (grus) commonly occurs.

Glaciofluvial and post-glacial alluvial deposits are mainly confined to river and stream valleys. Bedrock and colluvium are found in steep valleys and on mountains and ridges.

Des travaux de cartographie et d'échantillonnage des matériaux superficiels à l'échelle de 1/50 000 ont été effectués dans la région cartographique du lac California (SNRC 21 O/8). Des sols d'horizon B, des moraines de fond et des galets ont été échantillonnés dans 226 sites sur une étendue quadrillée de 2 km. La description du profil des sols et l'inventaire de la végétation ont été préparés. Les moraines feront l'objet d'analyses relatives à la teneur en or et à 33 autres éléments, ainsi qu'à certains métaux de base. Des travaux de cartographie détaillée et le prélèvement de 37 échantillons de moraines de fond aux fins d'analyse géochimique ont été effectués autour du gîte minéral de Halfmile Lake. Au total, 72 échantillons de moraines de fond ont été prélevés à l'intention du Centre de technologie de Noranda en vue d'essais géotechniques.

L'enregistrement de 700 stries, ainsi que de rainure et de roches moutonnées, indique un déplacement primitif des glaces vers l'est, suivi d'un écoulement de glaces en direction nord-est et sud-est. Des écoulements secondaires de glaces locales en stade final dans diverses directions ont suivi dans toute la région. Les structures des moraines reflètent un décalage graduel du déplacement des glaces d'est à sud-est. Des blocs erratiques granitiques, principalement du complexe intrusif du mont Elizabeth, indiquent un déplacement glaciaire jusqu'à 30 km en direction est-nord-est.

La majeure partie de la région est recouverte d'une mince couche de moraine de fond du Wisconsinien supérieur (1-2 m), qui peut être subdivisée en trois unités selon la texture, la composition, la topographie, le dépôt rocheux sous-jacent et la présence ou l'absence d'une couche sus-jacente de colluvium. La moraine est sableuse sur un dépôt rocheux granitique à l'endroit où se trouve habituellement une couche de dépôt de roches altérées préglaciaires (arène).

Les alluvions fluvioglaciaires et post-glaciaires sont principalement confinés aux vallées fluviales. On retrouve un dépôt rocheux et du colluvium dans les vallées profondes, sur les montagnes et les crêtes.

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[16]Contribution to the Canada - New Brunswick Cooperation Agreement on Mineral Development, 1990-95. Project carried by the Geological Surveys Branch of the New Brunswick Department of Natural Resources and Energy. The purpose of this project is to obtain geoscientific information that is useful for mineral exploration, mine reclamation, reforestation, land-use planning, and environmental applications.

INTRODUCTION

A two-year surficial mapping (1:50 000 scale) and till sampling (one sample per 4 km^2) program was begun in the California Lake (NTS 21 O/8) map area last year (Parkhill 1990). The California Lake map area lies in north-central New Brunswick, 60 km southwest of Bathurst along route 430 and 60 km northwest of Newcastle along route 430 (Figures 22 and 23). The California Lake map area was selected for study because of its proximity to and similarities in bedrock geology to previously mapped areas (Figure 22), favourability for mineral exploration, lack of coverage in previous till surveys, and simultaneous bedrock mapping by Reg Wilson (this volume) and Cees van Staal (this volume). The granular aggregate resources of the area were mapped in 1985 (Paradis *et al.* 1986). A till sampling survey was carried out in parts of the area from 1985-88 (Lamothe 1990). This project concentrates more on till mapping, grid sampling, and glacial history.

During the summer of 1991, mapping and sampling were completed in the California Lake map area. A total of 266 sites were sampled (pebbles, B- and C- horizons). In addition, vegetation inventories and soil-profile descriptions were recorded for forest-site-classification purposes. David Bance assisted in the 1991 mapping and sampling.

PHYSIOGRAPHY

The study area is located within two physiographic subdivisions; the Northern Miramichi Highlands and the Eastern Miramichi Highlands of the Appalachian Region of Canada (Rampton *et al.* 1984). The Miramichi Highlands is a rugged terrain underlain by Lower Palaeozoic sedimentary rocks and felsic and mafic igneous rocks. In the western part of the area, topography is strongly bedrock controlled with deeply incised V-shaped valleys and high mountains, including Mount Acquin at 666 m above sea level. Elevation is commonly between 450 m and 600 m. High mountains and ridges are generally angular and peaked in resistant volcanic rocks, but rounded and flat topped over intrusive (mainly granites) rocks. Toward the east, topography is gently rolling and hummocky with more U-shaped valleys and swamps. Local relief in the study area is up to 390 m.

Most of the rivers and brooks have deeply incised V-shaped valleys with local relief commonly greater than 200 m. Wide U-shaped valleys around Canoe Landing Lake, at Upsalquitch Lake, and along sections of the Nepisiguit River are a result of glacial action and were most likely glacial channelways. The Miramichi Highlands are generally well drained and have a dendritic to rectangular (structurally controlled) drainage pattern. The California Lake area is drained mainly by the Nepisiguit, Northwest Miramichi, and Upsalquitch river systems that flow radially off the Miramichi Highlands.

BEDROCK GEOLOGY

The California Lake map area is situated within the Miramichi tectonostratigraphic terrane (Fyffe and Fricker 1987) and is underlain by sedimentary rocks of the Cambro-Ordovician Miramichi Group, sedimentary and felsic and mafic volcanic rocks of the Ordovician Tetagouche Group, and mafic volcanic and sedimentary rocks of the Ordovician Fournier Group (van Staal 1990). The southwestern corner of the map sheet is underlain by the Silurian Mount Elizabeth Intrusive Complex (Figure 23) as well as other Silurian and Ordovician mafic and felsic intrusive rocks (Whalen 1990). There are 53 mineral occurrences listed in the New Brunswick Computerized Mineral Occurrence Database for the California Lake map area including the Heath Steele, Stratmat, Halfmile Lake, Wedge, Devils Elbow, and Canoe Landing Lake deposits (Rose and Johnson 1990).

QUATERNARY GEOLOGY

The glacial history of the area is consistent with other areas mapped to the west (NTS 21 O/7; Parkhill, in preparation) and to the north (NTS 21 O/9, 10, and 15, and parts of 22 B/1 and 2; Pronk and Parkhill 1991). Recording of 700 striation and or groove and roche moutonnée locations indicate a strongly erosive eastward-flowing ice movement (070° - 105°), followed by northeastward- (040° - 065°) and southeastward-flowing (130° - 150°) ice (Table 5). Northeastward-trending striae and grooves (040°) preceding the eastward ice movement have been documented at a few locations to the south of the Heath Steele mine. Minor late-stage ice, flowed

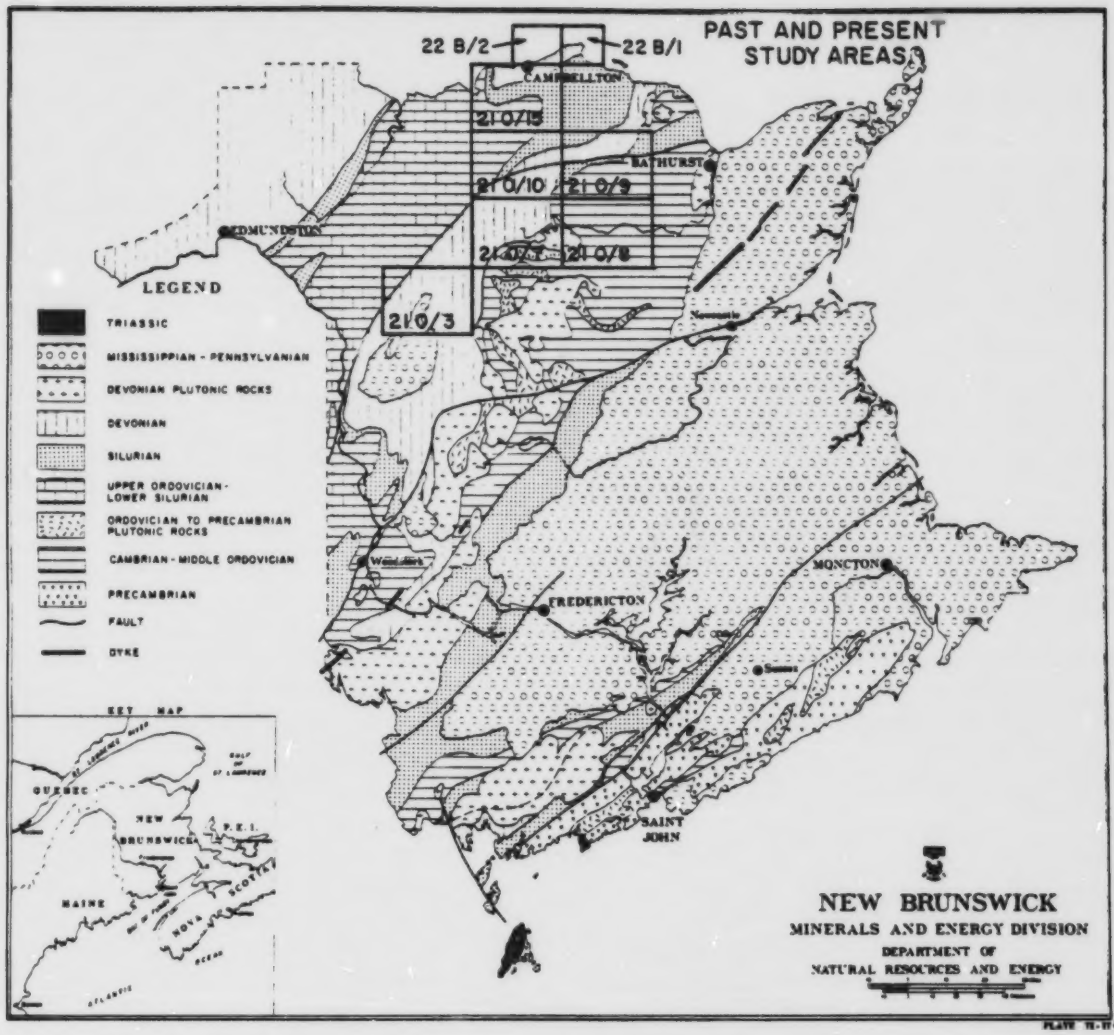

FIGURE 22. Location of Provincial surficial geology-till geochemistry projects in northern New Brunswick (1985-1991).

in various directions from local topographic highs throughout the area. Striations are better preserved on mafic volcanic and sedimentary rocks that generally underlie gently rolling topographic lows. Striations are more dominant on westward-facing (stoss) slopes than on down-ice (lee) slopes (Parkhill 1990).

A trench approximately 4 km northwest of California Lake (Figure 23) has revealed two basal tills, each approximately 1 m thick, separated by a 0.8 m thick layer of fluvial gravel. A till fabric, based upon measurement of the a axis of 50 pebbles was measured on each till. Pebble size was restricted to clasts having an a axis length greater than twice the b axis length. The main peak in the fabric for the lower till trends at 115° with a secondary peak at 95°, whereas the upper till fabric trends 145°. The fabrics correlate well with striae patterns documented in the same area. These results suggest that the tills were deposited by ice that was gradually shifting from an easterly to southeasterly direction. No evidence for the northeastward ice movement was obtained from the fabrics.

A train of granite-boulder erratics has been mapped throughout the area. This indicates glacial transport of up to 30 km in an east-northeast direction from a source area in the Mount Elizabeth Intrusive Complex and

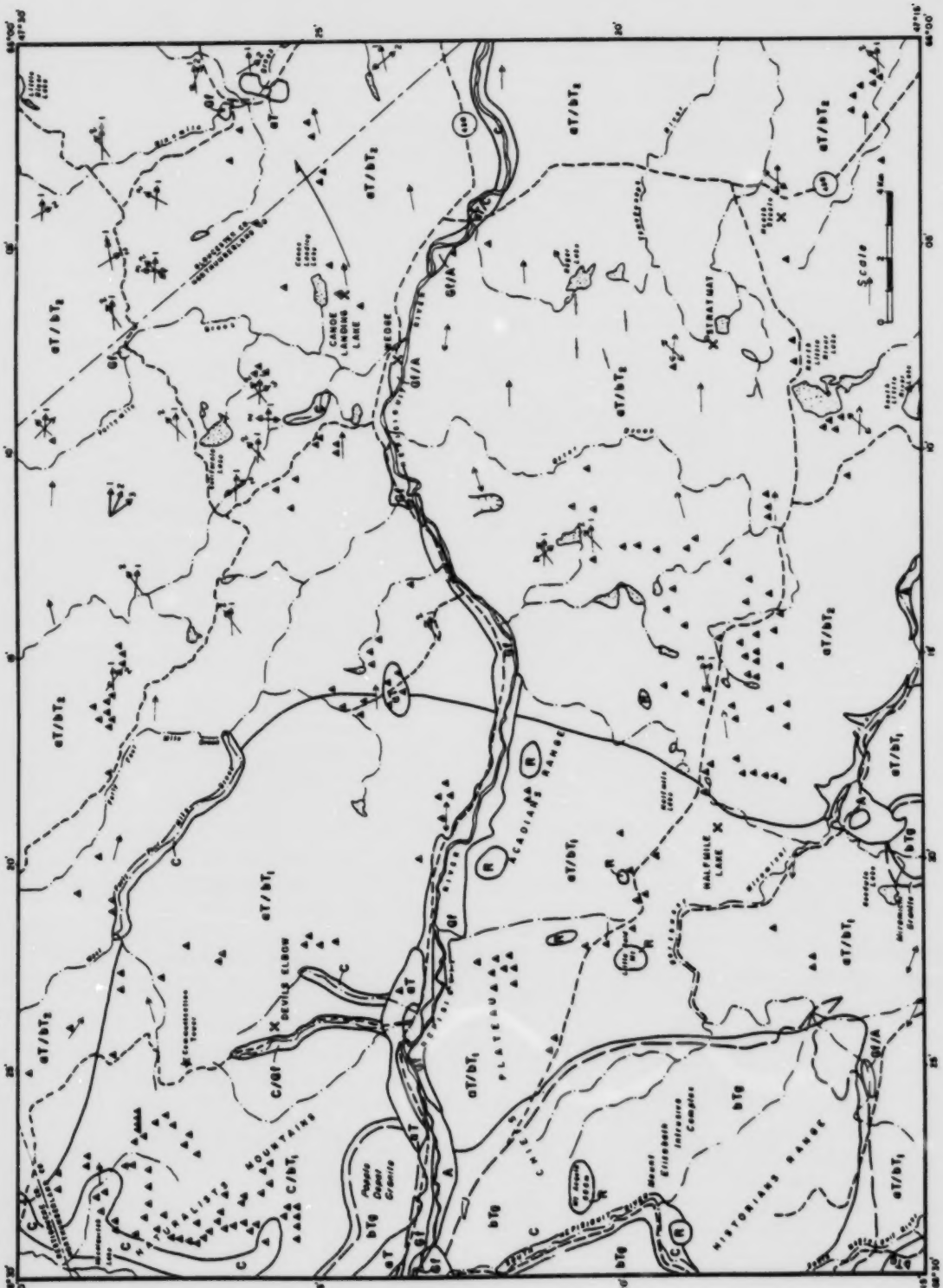

FIGURE 23. Preliminary surficial geology of the California Lake (NTS 21 O/8) map area.

Legend

AGE	UNIT	DEPOSIT
QUATERNARY		
HOLOCENE	C	Colluvial (minor patches of till)
	A	Alluvial (sand and gravel)
LATE WISCONSINAN		**Glaciofluvial**
	Gf	Outwash and ice-contact (mainly sand and gravel, minor cobbles and boulders, may be stratified)
		Glacial
	aT/bT_1 | aT/bT_2 | bTg	Mainly greenish to yellowish brown basal till, minor ablation till and in places ablation lag over basal till; aT/bT_1 - coarse, sandy/gravelly to sandy/clayey/ loamy till veneer (< 1m) often overlain by colluvium; mainly felsic volcanic and minor sedi- mentary clasts. aT/bT_2 - fine to coarse, sandy/clayey/loamy till (> 1m); sedimentary and felsic and mafic igneous components. bTg - coarse sandy/gravelly granitic till, generally thin (<1m), reddish to yellowish brown; discontinous over deeply weathered bedrock (grus) and bedrock.
PRE-QUATERNARY		
	R	Bedrock

Symbols

- Glacial striae (direction known, unknown)
- Relative age of striae (1) older, (2) younger
- Roche moutonnée
- Till clast fabric, inferred ice direction
- Drumlinized bedrock
- Cirque-like feature
- Boulder erratic
- Meltwater channel
- Morphogenetic boundary
- Bedrock contact (source of boulder erratics)
- Mineral deposit
- Major access roads
- Major rivers and streams

TABLE 5. STRIAE, GROOVE, AND ROCHE MOUTONNÉE MEASUREMENTS, CALIFORNIA LAKE MAP AREA.

AZIMUTH	NUMBER OF MEASUREMENTS(*=1) TOTAL = 700
001-005	*
006-010	*
011-015	
016-020	
021-025	*****
026-030	**
031-035	*****
036-040	*******
041-045	******************
046-050	*************
051-055	*********
056-060	**************
061-065	********************
066-070	*************
071-075	**
076-080	**> = 72
081-085	**> =142
086-090	**> =130
091-095	**> = 79
096-100	**
101-105	****************************
106-110	*********
111-115	******
116-120	******
121-125	**
126-130	*
131-135	****
136-140	***
141-145	****
146-150	****
151-155	*
156-160	**
161-165	
166-170	
171-175	*
176-180	********

the Popple Depot and Miramichi granites (Whalen 1990). Granite boulders found in the Nepisiguit River valley and in a large meltwater channel in the Canoe Landing Lake area were fluvially, as well as glacially transported, from the Mount Elizabeth Intrusive Complex and the Popple Depot Granite (Whalen 1990).

A generally thin (less than 2 m) layer of greenish to yellowish brown basal till of Late Wisconsinan age covers most of the area. The till can be subdivided into three units based on; texture, composition, topography, underlying bedrock, and the presence or absence of an overlying layer of colluvium. These units are designated aT/bT_1, aT/bT_2, and bTg on Figure 23. Unit aT/bT_1 occurs in the western part of the map area where terrain is rugged (elevation greater than 500 m). The till is a generally coarse, monolithologic, sandy/gravelly to sandy/loamy/clayey veneer (less than 1 m) that is commonly overlain by a layer of colluvium. Mapping of recent exploration trenches for regolith information has revealed that in parts of the area, colluvium, 0.5 to 1 m thick,

overlies up to 3 m of sandy-clayey-loamy basal till. Basal till in the eastern part of the area (Unit aT/bT_2); is thicker (greater than 1 m) than in the western part of the area, has a higher clay content, lacks an overlying veneer of colluvium, and reflects a diverse bedrock geology. Topography is gently rolling and hummocky. Basal till over granite bedrock (Unit bTg) is reddish to yellowish brown, coarse, sandy/ gravelly, generally thin and often overlies a layer of *in situ* preglacial weathered bedrock (grus). The grus is very friable and retains the original structure and mineralogy of the rock. This grus is also found over mafic intrusive rocks. Thick layers (greater than 2 m) of weathered bedrock have been found over sedimentary rocks west of Little Bald Mountain. *In situ* weathered bedrock is not restricted to areas underlain by intrusive rocks but seems restricted to elevations higher than 500 m. A lack of striations, grooves, and roche moutonnée in the topographically higher western part of the area suggests that glacial erosion was not as intense as at lower elevations to the east. This difference in elevation probably accounts for this preservation of preglacial weathered bedrock in the west. Ablation till occurs as a thin lag deposit over basal till or as a thick (greater than 2 m) deposit in some river and stream valleys. Ablation till is commonly present as a mantle of boulders on the surface.

In areas of high relief, and on the mountains and ridges that are mostly underlain by felsic volcanic and intrusive rocks, frost shattering and a lack of thick till deposits has created a layer of gravelly to bouldery colluvium (Unit C on Figure 23) or rock veneer with small patches of thin basal till. Many mountains and ridges are outcrop (Unit R on Figure 23). Steep V-shaped valleys are generally covered with colluvial material.

Large thick deposits of glaciofluvial outwash and ice-contact kames and eskers (Unit Gf on Figure 23) are found along the Nepisiguit River valley, with smaller deposits located in other river and stream valleys. Recent alluvial deposits (Unit A on Figure 23) are present in many valleys.

Preliminary investigation of pebble samples from basal till indicates that the tills are predominately composed of locally derived bedrock material (less than 2 km transport distance) with some distally transported granite clasts (up to 30 km). A reference suite of bedrock samples was collected from the area to assist in a lithological analysis of the till pebble size fraction.

GEOCHEMISTRY

The samples will be prepared at the New Brunswick Department of Natural Resources and Energy's geochemistry laboratory in Fredericton. The minus 0.177 mm fraction of the B-horizon soils will be analysed in-house for Cu, Pb, Zn, Mn, Fe, Co, Ni and Ag by Atomic Absorption. The minus 0.063 mm (silt-plus-clay) fraction of the basal till will be sent out for geochemical analysis (Table 6). Pan concentrates on selected samples will be analysed in a comparison study.

TABLE 6. TILL GEOCHEMICAL PACKAGE.

"GOLD + 33" by Direct Irradiation/INAA				Plus selected Base Metals by Atomic Absorption
Gold	Cobalt	Rubidium	Thorium	Cadmium
Antimony	Europium	Samarium	Tin	Copper
Arsenic	Hafnium	Scandium	Tungsten	Lead
Barium	Iridium	Selenium	Uranium	Manganese
Bromine	Iron	Silver	Ytterbium	Mercury
Cadmium	Lanthanum	Sodium	Zinc	Silver
Cerium	Lutetium	Tantalum	Zirconium	Vanadium
Cesium	Molybdenum	Tellurium		Zinc
Chromium	Nickel	Terbium		

ENVIRONMENTAL APPLICATIONS

At 35 sample sites, an extra sample of basal till was collected for Noranda Technology Center of Montreal. These samples will be analysed for geotechnical information to delineate suitable overburden (high-clay/low-pebble content) to be used for covering tailings ponds and waste piles in the Heath Steele Mines area. All information obtained by Noranda will be made available to the Geological Surveys Branch.

A 1:10 000-scale study of the surficial deposits and their geotechnical and geochemical properties was conducted in the fall of 1991 around the Halfmile Lake mineral deposit. A total of 37 samples was taken on a 500 m grid. An extra sample was taken at each of these sites for Noranda Technology Center. This was done in conjunction with a stream-sediment and water sampling program in the same area by Toon Pronk (this volume). This is being done to assess (1) the glacial dispersal of geochemical anomalies; (2) the background geochemistry in waterways draining the Halfmile Lake mineral deposit, prior to any mining operation; and (3) to determine the availability of suitable overburden for mine-reclamation purposes. No results were available at the time of writing.

Forest-site–classification information obtained from this study can be used for planning reforestation projects. Suitable tree species can be selected to match different regolith (soil) units.

A report and maps at 1:50 000 and 1:10 000 scale will be produced. They will be useful for mineral exploration, mine reclamation, reforestation, and land-use planning applications.

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ANTINOURI-NICHOLAS MINERAL OCCURRENCE PROJECT, GLOUCESTER AND RESTIGOUCHE COUNTIES, NEW BRUNSWICK[17]

W.W. Gardiner
Mineral Deposits Geologist

Mineral occurrences in the Antinouri Lake-Nicholas Dénys project area, northwest of Bathurst, are being examined in order to provide a more comprehensive mineral inventory for New Brunswick. This study is being carried out concurrently with a regional bedrock mapping program in the same area. A total of two hundred and forty-three mineral occurrences have been identified, with one hundred and seventy-seven having been field-checked in 1990-91. Data collected on these mineral occurrences will be incorporated into the computerized mineral occurrence database and will provide basic information for a metallogenic study of the area as an aid to mineral exploration.

Les gîtes minéraux du secteur d'analyse du Lac Antinouri-Nicholas Dénys, au nord-ouest de Bathurst, font l'objet d'études afin de fournir un inventaire plus détaillé des minéraux du Nouveau-Brunswick. Cette étude est menée simultanément à un programme régional de cartographie du substrat rocheux dans la même région. Un total de 243 gîtes minéraux ont été relevés, dont 177 ont été vérifiés sur le terrain en 1990-1991. Des données recueillies sur ces gîtes minéraux seront incorporées à la base de données informatisée sur les gîtes minéraux; ils fourniront des renseignements généraux aux fins d'étude métallogénique du secteur visant à aider l'exploration minière.

INTRODUCTION

This project was initiated in 1990 in conjunction with a bedrock mapping study of the Antinouri-Nicholas area (Walker *et al.*, this volume). To date, a total of two hundred and forty-three occurrences have been identified in the study area (Figure 15), seventy-nine of which are presently included in the New Brunswick computerized mineral occurrence database. The majority of the new occurrences will be entered into the mineral occurrence file in the next few months. One hundred and thirty-five (for a two-year total of one hundred and seventy-seven) were field-checked this year. Data from the field-checking will include more accurate locations for the Province's Geographic Information System (GIS), new occurrences, and updated information on known occurrences to the computerized mineral occurrence file. Samples from many of the occurrences, from the mineralized zones and their host rocks, were collected to identify the genetic types and commodities present. Representative samples are being analysed by multi-element techniques, and thin and/or polished sections of the mineralized samples are being prepared to determine mineralogy, mineral textures, and where possible, paragenetic sequences of the mineralizing processes. The mineral occurrences have been tentatively classified as to type (Table 7). Field work related to each occurrence involves pin-pointing the location, sampling for multi-element analysis, slabbing and thin-sectioning, as well as describing the occurrence to fully understand its geological setting and geometry.

VEIN GOLD OCCURRENCES

There are three types of vein gold occurrences in the area. Type A occurrences vary in appearance somewhat but are generally typified by the Zarina occurrence (Occurrence #80). The gold is generally contained in narrow quartz veins with associated pyrite, minor arsenopyrite, and locally, base metals. A number of these veins occur immediately north of the Rocky Brook-Millstream Break and strike in a northwest direction. Gold

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[17]This project is being carried out to augment the Antinouri-Nicholas project. The project is aimed at providing the mineral exploration industry with a mineral occurrence database for the region, and geological models useful in mineral resource exploration.

TABLE 7. MINERAL OCCURRENCE DEPOSIT TYPES

DEPOSIT TYPE	NO. OF OCCURRENCES
Vein Au - A	10
Vein Au - B	3
Vein Au - C	7
Mafic dyke Au	5
Miscellaneous Au	10
Granite-related Mo-Cu-F-W-Sn	9
Vein/breccia/stratabound Cu-Ba-Pb-Zn-Ag	25
Vein Pb-Zn-Ag-Cu - A	29
Vein Pb-Zn-Ag-Cu - B	15
Vein/stringer Pb-Zn-Ag ± Sb ± F	15
Skarn - (Silurian-hosted)	29
Skarn - (Ordovician-hosted)	5
Ophiolite-hosted Cu, etc.	7
Mafic/ultramafic Ni-Pb-Zn	15
Manganese	4
Massive sulphide	4
Miscellaneous or unclassified	51
Total	243

contents can be high (0.5 oz./Ton or 17.1 g/t Au) but vein widths tend to be low. Type B veins are predominantly massive arsenopyrite-quartz veins and are typified by the Stephens Brook mine (Occurrence #434). Gold contents rarely exceed 0.2 oz./Ton (6.9 g/t) from these occurrences. Type C veins are arsenic-free quartz veins where gold is contained within pyrite and are typified by the Nigadoo gold veins.

MAFIC DYKE-RELATED GOLD OCCURRENCES

This type can be divided into two categories; gabbro-related and diabase-related. The Eimtree West Gabbro zone (Occurrence #454) is the only example of the former. Gold-bearing sulphides occur as disseminations and in veins within a wide carbonate-altered Ordovician gabbro that is probably in tectonic contact with Elmtree mélange. The diabase-related deposits, such as the Millstream West deposits (Occurrences #344, 914-916), generally contain gold associated with fine needle-like arsenopyrite crystals in quartz-carbonate veins along the margins of the dykes, and less frequently, within the dykes that intrude Silurian rocks. The more abundant these arsenopyrite crystals become, the higher the grade of gold. Assays of close to 1 oz./Ton (34.29 g/t) can be attained over narrow widths, but lower gold values (0.1-0.2 oz./Ton or 3.4-6.9 g/t) can be attained over several metres width.

MISCELLANEOUS GOLD OCCURRENCES

These two occurrences are of gold-bearing, fine-grained, acicular arsenopyrite disseminated in Silurian grits to fine pebble conglomerates. They may represent remobilized paleo-placer deposits. Gold values range as high as 4300 ppb and may be widespread.

GRANITE-RELATED MO-CU-F-W-SN ± PB-ZN OCCURRENCES

These occurrences fall within the broad classification of porphyry molybdenum deposits. They occur both within the granites and within the surrounding contact metamorphic aureole. Most of the occurrences are

associated with the Nicholas Dénys Granodiorite, although a few occurrences are found in the southwestern part of the Antinouri Lake Granite. The occurrences are composed of disseminated and stringer sulphides with molybdenum predominating over copper. Fluorite, scheelite, and tin occur as minor (to locally important) constituents of some of these occurrences.

VEIN/BRECCIA/STRATABOUND CU-BA-PB-ZN-AG OCCURRENCES

These occurrences are restricted to the eastern half of the Jacquet River graben. They are generally contained within breccias of various types and occasionally within limestone. The copper and barite may be present as disseminations, as veinlets (stringers), or be contained in quartz veins within the breccias. The breccia types are currently under study; they probably include flow-top breccias (mafic flows), hydrothermal breccias, volcanic breccias, and possibly tectonic breccias. The bulk of the mineralization appears to be syn- to early post-volcanic in origin as indicated by associated agates in the veins and vesicles. These occurrences are of minor importance, but may be related to the larger Nash Creek deposit.

VEIN PB-ZN-AG-CU OCCURRENCES

This group of occurrences can be further subdivided into (A) Silurian- and (B) Ordovician-hosted deposits. The Ordovician occurrences are typified by the Keymet vein system (Occurrence #368) whereas the Silurian occurrences are represented by the Nigadoo veins (Occurrence #128). There are a few significant differences in these vein types, although their origins may be related. The association of fluorite, and locally tin and tungsten, with many of these veins may indicate a relationship to the Devonian granites in the area.

VEIN-STRINGER PB-ZN-CU-AG ± SB ± F OCCURRENCES

These base-metal occurrences are found near the Rocky Brook-Millstream fault zone as stringers, veins, and lenses paralleling the main foliation. Occurrences peripheral to the zone occupy tensional features at 130-140° as part of a splay fracture system related to the shearing. Minor gold, arsenic, and green fluorite are present in these occurrences. Occurrences of this type include the Hachey and Shaft deposits.

SKARN BASE METALS AND/OR IRON (STRATABOUND) OCCURRENCES

These stratabound deposits occur within limestones or calcareous argillites that have been contact metamorphosed by the Antinouri Lake and Nicholas Dénys intrusions to coarse-grained calc-silicate assemblages and porcelanites. The most significant Silurian (A) deposits are the Patapat Brook (Ag, Cu, Pb, Zn), Millstream (Fe), and Beresford (Cu) deposits. In many of these deposits, the iron occurs as coarsely banded magnetite. The base metals, tungsten, and molybdenum cross-cut the iron and are clearly related to the granites in the area. The best Ordovician (B) deposits are the Madran deposits (Pb-Zn-Ag). The nature of these deposits is unclear at present.

OPHIOLITE-HOSTED CU OCCURRENCES

The ophiolite-hosted copper occurrences are best typified by the Turgeon deposit (Occurrence #16). Other occurrences are primarily copper disseminations in ophiolitic basalts. No work was done on these deposits this year.

MAFIC/ULTRAMAFIC NI-ZN-PB-TALC-ASBESTOS OCCURRENCES

These occurrences have been recognized for a number of years, but their relationship to altered mafic/ultramafic allochthonous slabs has only recently been observed. The mafic/ultramafic bodies are generally conformable to the host Ordovician metasediments and strike 060-080°. Base-metal mineralization appears to be confined to the margins of the bodies, whereas the nickel is both within and marginal to them. The ultramafic slabs are highly bleached and altered. Gold and antimony enrichments are localized. Talc, serpentine, and poor-quality asbestos are found in some altered peridotites.

MANGANESE OCCURRENCES

There are occurrences of red manganiferous shales (RMS) in the Ordovician fournier Group, which are enriched in many metals. They are useful in determining the potential stratigraphic positions of massive sulphide deposits. At least one has associated elevated gold values.

MASSIVE SULPHIDE DEPOSITS

Several massive sulphide occurrences are found in Tetagouche Group rocks along the southern margin of the map area. These stratiform sulphide occurrences contain banded pyrite, Cu, Pb, Zn, and Ag. The two main deposits in the area are the Orvan Brook and Rocky Turn deposits.

MISCELLANEOUS OR UNCLASSIFIED OCCURRENCES

These occurrences are generally base-metal deposits on which insufficient data have been collected.

ANTINOURI-NICHOLAS GEOSCIENCE DATA COMPILATION PROJECT; GLOUCESTER AND RESTIGOUCHE COUNTIES, NEW BRUNSWICK (C-NBCAMD)[18]

Paul Rennick
Project Geologist

INTRODUCTION

This project, now in its second year, is a continuation of geoscience data compilation that has been ongoing since 1984. It is being carried out in conjunction with geological mapping and mineral occurrence studies in the Antinouri Lake - Nicholas Dénys area, northwest of Bathurst (Figure 15). Data have been compiled for map sheets 21 O/16a, 21 P/12e, and 21 P/13d. Compilation is in progress for map sheets 21 P/12f, g, and 21 P/12b, c.

Graphic and textural data are being compiled at a scale of 1:20 000 in coordination with both the geological mapping and mineral occurrence investigation studies in progress. When compiled, the data are input to the CARIS-based Geoscience Information System (GSIS).

COMPILATION PROCEDURES

The procedures involved in geoscience data compilation consist of data collection, compilation, conversion-integration, and storage (Rennick 1990). The data are collected by 1:20 000 map area, and compiled onto graphical layers with associated thematic databases. For each 1:20 000 map, data are divided into six thematic layers starting with the topographic base map. The base maps used are digital 1:50 000-scale bases obtained from Energy, Mines and Resources, Ottawa. The remaining graphical data are digitized from compiled hard-copy maps into thematic digital layers that overlie the existing base map.

The thematic digital layers consist of geoscientific and mineral exploration assessment data. The geoscientific data are divided into four thematic layers consisting of geological (including diamond drilling) surveys as layer two; geophysical surveys as layer three; geochemical surveys as layer four; and a fifth annotation layer, composed of duplicate, replicate, and poorly located data from layers 2, 3, and 4. The final thematic layer consists of mineral exploration assessment work locations that are obtained from 1:50 000 NTS bases.

DATABASES

The databases used for this project follow the form of those initiated for the compilation project for map sheet 21 P/5 (Appendix I). Five databases containing information on "GEOSCAN", geological surveys, geochemical surveys, geophysical surveys, and airborne geophysical surveys were used to record the thematic data sets. Databases containing information from diamond drilling, modelled after those used in mineral deposit studies, were also created for each map sheet (Appendix II). These four databases contain information pertaining to drill-collar location, drill-hole deviation, assay-interval information, and lithologic-interval information.

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[18]Contribution to the Canada - New Brunswick Cooperation Agreement on Mineral Development, 1990-95. Project carried by the Geological Surveys Branch of the New Brunswick Department of Natural Resources and Energy. This project deals with a compilation of all geoscience data, mostly private, residing in the Province's mineral assessment files. The data are being entered into a CARIS-based geoscience information system so as to be used more efficiently and effectively in the search for hidden mineral deposits.

PROJET DE COMPILATION DES DONNÉES SCIENTIFIQUES D'ANTINOURI-NICHOLAS; COMTÉS DE GLOUCESTER ET RESTIGOUCHE, NOUVEAU-BRUNSWICK (ECCNBEM)

Paul Rennick
Géologue d'études

INTRODUCTION

Ce projet, maintenant à sa deuxième année, est une continuation de la compilation des données géoscientifiques en cours depuis 1984. Le projet a pour emplacement la région du lac Antinouri, au nord-ouest de Bathurst, Nouveau-Brunswick (Figure 15). Des données ont été compilées pour les feuilles topographiques 21 O/16a, 21P/12e et 21 P/13d. La compilation se poursuit pour les feuilles topographiques 21 P/12f, g et ? P/12b, c.

On est en train de compiler ces données graphiques et texturales à l'échelle de 1/20 000 conformément aux études de cartographie géologique et d'enquête sur les gîtes minéraux en cours. Lorsqu'elles seront compilées, les données seront introduites dans le système d'information géoscientifique utilisant CARIS (GSIS).

MÉTHODE DE COMPILATION

La méthode de compilation des données géoscientifiques consiste à recueillir, compiler, convertir-intégrer et mémoriser les données (Rennick 1990). Les données sont recueillies par régions cartographiques à l'échelle de 1/20 000, et elles sont compilées par couches graphiques avec les bases de données thématiques associées. Dans le cas de chaque carte à l'échelle de 1/20 000, les données sont réparties en six couches thématiques, en commençant avec le fond de carte topographique. Les fonds de cartes utilisés sont des fonds numériques à l'échelle de 1/50 000 obtenus d'Énergie, Mines et Ressources Canada. Les données graphique qui restent sont numérisées à partir des copies papier des cartes compilées par couches numériques thématiq recouvrant le fond de carte existant.

Les couches numériques thématiques sont constituées des données géoscientifiques et des données d'évaluation de la prospection minière. Les données géoscientifiques sont réparties en quatre couches thématiques composées d'études géologiques (y compris le forage au diamant) et sont appelées couche deux; les études géophysiques sont représentées par la couche trois; les études géochimiques, par la couche quatre; les annotations, par la couche cinq, composée des duplicata, des reproductions et des données médiocrement situées des couches 2, 3 et 4. La dernière couche thématique comprend les emplacements des travaux d'évaluation des explorations minières obtenus des bases du SNRC (Système national de référence cartographique) à l'échelle de 1/50 000.

BASES DE DONNÉES

Les bases de données employées pour ce projet suivent la forme de celles amorcées pour le projet de compilation relatif de la feuille topographique 21 P/5 (Annexe II). Cinq bases de données renfermant de l'information sur «GEOSCAN», des études géologiques, des études géochimiques, des études géophysiques et des études géophysiques aériennes, ont été utilisées pour enregistrer les ensembles de données thématiques. Des bases de données renfermant de l'information obtenue grâce au forage au diamant, modélisées d'après celles utilisées dans les études des gisements miniers, ont également été créées pour chaque feuille topographique (Annexe II). Ces quatre bases de données contiennent de l'information au sujet de l'emplacement des masses-tiges, de la déviation des trous de forage, des intervalles de teneurs et des intervalles lithologiques.

APPENDIX I

GEOSCAN DATABASE STRUCTURE

Field	Field Name	Description
1	TIT_MON	Name of company or individual that filed the report
2	AUTH_MON	Author('s) of the report
3	GEOSCAN	Geoscan reference number for the report
4	PUB_DATE	Year of report submittal
5	COMPANY	Name of companies which carried out the various surveys
6	COMPANY_1	Additional company names
7	REL_DATE	Date after which the report is no longer confidential
8	GEO_AGE	Generalized geologic age of rocks in area
9	KEYWORD	Keywords relating to surveys
10	NAME_DESC	Geologic region or zone of work area
11	SUBJ_CAT	Keywords relating to the report
12	NTS	Map sheet('s) covered by the surveys
13	PROV	Province the work was carried out in
14	ILLUST	Illustrations, type, if present
15	MAP_PRES	Maps included with report "Y" or "N"
16	NO_MAPS	Number of maps included
17	CLAIM_ID	Name identifying the claim block for which the work was recorded
18	REL_REF_D	Related or referenced assessment records
19	LAT	Latitude
20	LONG	Longitude
21	MAP_NAME	Name description for map
22	G_MAP_TP	General map types (ex. geophys.)
23	SP_MAP_TP	Specific types of maps included
24	SCALE	Scale of maps included
25	FUR_INFO	Additional information

GEOLOGICAL SURVEYS DATABASE

Field	Field Name	Description
1	GEOSCAN	Assessment report file reference number
2	COMPANY	Name of company or individual that filed the assessment report
3	PROPERTY	Name of claim block of assessment report
4	YEAR	Year of report submittal
5	SURVEYTYPE	Type of geological surveys reported
6	MAP_SCALE	Scale of map
7	COVERAGE	Area covered by the survey
8	MISC	Miscellaneous information (ex. drilling)
9	G_PLOT_REL	Reliability of plotting (1 -> 6)
10	G_PLOT_REF	Plotting references (grid,claims,topo)
11	GPLOT_STAT	Compiler (GSB - Geological Surveys Branch)
12	G_NTS_NO1	NTS sheet covered by the work report
13	G_MAP_NO1	Names of 1:20,000 maps for NTS sheet

14	G_NTS_NO2	Second NTS sheet covered by report
15	G_MAP_NO2	Names of 1:20,000 maps for second NTS map
16	G_NTS_NO3	Third NTS sheet covered by report
17	G_MAP_NO3	Names of 1:20,000 maps for third NTS map
18	G_NTS_NO4	Fourth NTS sheet covered by report
19	G_MAP_NO4	Names of 1:20,000 maps for fourth NTS map

GEOCHEMICAL SURVEYS DATABASE

Field	Field Name	Description
1	GEOSCAN	Assessment report file reference number
2	COMPANY	Name of company or individual that filed the assessment report
3	PROPERTY	Name of claim block of assessment report
4	YEAR	Year of report submittal
5	SURVEYTYPE	Type of geochemical survey reported
6	CONTRACTOR	Name of contractor(if used or reported)
7	MEDIA_SAMP	Sample type (soil, silt, till)
8	ANALYSES	Element analysed
9	DIGESTION	Method of analyses
10	MISC	Miscellaneous information
11	C_PLOT_REL	Reliability of plot(1 -> 6)
12	C_PLOT_REF	Plotting reference(grid, claims, topo)
13	CPLOT_STAT	Compiler(GSB - Geological Surveys Branch)
14	C_NTS_NO1	NTS sheet covered by the work report
15	C_MAP_NO1	Names of 1:20,000 maps for NTS sheet
16	C_NTS_NO2	Second NTS sheet covered by report
17	C_MAP_NO2	Names of 1:20,000 maps for second NTS map
18	C_NTS_NO3	Third NTS sheet covered by report
19	C_MAP_NO3	Names of 1:20,000 maps for third NTS map
20	C_NTS_NO4	Fourth NTS sheet covered by report
21	C_MAP_NO4	Names of 1:20,000 maps for fourth NTS map

GEOPHYSICAL SURVEY DATABASE

Field	Field Name	Description
1	GEOSCAN	Assessment report file reference number
2	COMPANY	Name of company or individual that filed the assessment report
3	PROPERTY	Name of claim block of assessment report
4	YEAR	Year of report submittal
5	SURVEYTYPE	Type of geophysical survey reported
6	CONTRACTOR	Contractor who carried out the survey if different from "COMPANY"
7	MISC	Miscellaneous information
8	P_PLOT_REL	Reliability of plot(1 -> 6)
9	P_PLOT_REF	Plotting reference(grid, claims, topo)
10	PPLOT_STAT	Compiler(GSB - Geological Surveys Branch)
11	P_NTS_NO1	NTS sheet covered by the work report
12	P_MAP_NO1	Names of 1:20,000 maps for NTS sheet
13	P_NTS_NO2	Second NTS sheet covered by report
14	P_MAP_NO2	Names of 1:20,000 maps for second NTS map

15	P_NTS_NO3	Third NTS sheet covered by report
16	P_MAP_NO3	Names of 1:20,000 maps for third NTS map
17	P_NTS_NO4	Fourth NTS sheet covered by report
18	P_MAP_NO4	Names of 1:20,000 maps for fourth NTS map

AIRBORNE GEOPHYSICAL SURVEYS

Field	Field Name	Description
1	GEOSCAN	Assessment report file reference number
2	COMPANY	Name of company or individual that filed the assessment report
3	PROPERTY	Name of claim block of assessment report
4	YEAR	Year of report submittal
5	SURVEYTYPE	Type of survey flown
6	CONTRACTOR	Name of contractor that conducted the survey
7	FLIGHT_ALT	Altitude in metres the survey was flown
8	FLTLINEDIR	Flight line direction (from T.N.)
9	FLTLINSPAC	Flight line spacing in metres
10	MISC	Miscellaneous information
11	A_PLOT_REL	Reliability of plot(1 -> 6)
12	A_PLOT_REF	Plotting reference(grid, claims, topo)
13	APLOT_STAT	Compiler(GSB - Geological Surveys Branch)
14	A_NTS_NO1	NTS sheet covered by the work report
15	A_MAP_NO1	Names of 1:20,000 maps for NTS sheet
16	A_NTS_NO2	Second NTS sheet covered by report
17	A_MAP_NO2	Names of 1:20,000 maps for second NTS map
18	A_NTS_NO3	Third NTS sheet covered by report
19	A_MAP_NO3	Names of 1:20,000 maps for third NTS map
20	A_NTS_NO4	Fourth NTS sheet covered by report
21	A_MAP_NO4	Names of 1:20,000 maps for fourth NTS map

APPENDIX II

DRILLHOLE COLLAR DATABASE

Field	Field Name	Description
1	GEOSCAN	Assessment report index file number
2	HOLE_NAME	Drillhole name from compilation project
3	COMP_NAME	Drillhole name from assessment report
4	EASTING	Ground co-ordinates (UTM) in metres
5	NORTHING	Ground co-ordinates (UTM) in metres
6	ELEVATION	Elevation of collar in metres
7	AZIMUTH	Azimuth (True North) at drillhole collar
8	DIP	Orientation at collar below horizontal
9	LENGTH	Length of drillhole from collar

DRILLHOLE DEVIATION FILE

Field	Field Name	Description
1	GEOSCAN	Assessment report index file number
2	HOLE_NAME	Drillhole name from compilation project
3	DEPTH	Depth from collar of drillhole orientation test
4	AZIMUTH	Azimuth at tested depth
5	DIP	Dip at tested depth

DRILLHOLE ASSAY INTERVAL DATABASE

Field	Field Name	Description
1	HOLE_NAME	Drillhole name from compilation project
2	FROM	Start of interval in metres from collar
3	TO	End of interval in metres from collar
4	CU	Copper in percent
5	PB	Lead in percent
6	ZN	Zinc in percent
7	AG	Silver in oz./Ton
8	AU	Gold in oz./Ton
9	MOS2	Molybdenum in percent
10	GEOSCAN	Assessment report index file number

DRILLHOLE LITHOLOGIC INTERVAL DATABASE

Field	Field Name	Description
1	HOLE_NAME	Drillhole name from compilation project
2	FROM	Start of interval in metres from collar
3	TO	End of interval in metres from collar
4	LITHUNIT	Abbreviation of lithologic unit
5	GEOSCAN	Assessment report index file number

REFERENCE

RENNICK, P. 1990. Antinouri-Nicholas Project, Geoscience Data Compilation, Gloucester and Restigouche counties, New Brunswick (MDA). *In* Project Summaries for 1990, Fifteenth Annual Review of Activities. *Edited by* S.A. Abbott. New Brunswick Department of Natural Resources and Energy, Mineral Resources, Information Circular 90-2, pp. 115-117.

NOTES

GEOLOGICAL SURVEYS BRANCH

SUSSEX REGIONAL OFFICE

NOTES

ACTIVITIES OF THE SUSSEX REGIONAL OFFICE[19]

A.A. Ruitenberg
Regional Geologist

Staff of the Sussex Regional Office in 1991, consisted of Arie A. Ruitenberg (Regional Geologist), Malcolm McLeod (Assistant Regional Geologist), Maurice Mazerolle (Engineering Technician and Claims Inspector), and Freda Kelly (Administrative Services Officer). Alain Caron and Susan Johnson were employed under the C-NBCAMD. David Rose completed his MDA contract assignment in March and continued working in the field with provincial funding. Summer field staff included Kenneth Jones, Jeffrey Earle, Michelle Luscombe, and Jason Ross.

PROGRAMS AND PROJECTS

M.J. McLeod and A.A. Ruitenberg continued field checking problem areas in parts of 21 G and 21 H. After returning from maternity leave in August, Susan Johnson continued geological map compilation. Three 1:50 000 geological maps, 90-152, 90-153, and 90-154 (21 G/9, 21 H/12 and H/13), were field checked and compiled. A preliminary geologic-metallogenic map of 21 G at a scale of 1:250 000 was also prepared. The main emphasis of the field work was on regional correlation in the St. Croix and Avalon terranes in the southwestern part of the Province, and delineation of economically significant mineral belts. The field work was complemented with a U-Pb dating program conducted in cooperation with Dr. T.E. Krogh of the Royal Ontario Museum in Toronto.

A. Caron and K. Jones mapped the geology and numerous mineral occurrences associated with skarn zones along the contact aureole of the Pokiok Batholith to the southwest and northeast of the Lake George Antimony-Gold deposit. Relationships between veins, associated rock alteration, and structures in the various skarn zones were emphasized. This information is being integrated with geological data obtained last year from underground mapping at the Lake George deposit and drill-core logging. The field data will also be correlated with the detailed airborne magnetic gradiometer and VLF-EM maps produced under the auspices of the Geological Survey of Canada during the summer and fall of 1991.

D.G. Rose located and described several additional mineral occurrences covered by the 1:250 000 scale map sheet 21 G and 21 H. Samples were cut with a diamond saw and representative mineralized material was sent for assay. The results of the investigation were used to update the computerized mineral occurrence file.

J.M. Mazerolle, in cooperation with Paul Rennick, conducted computer modelling of geochemical stream-sediment data in 21 G/14E to compliment the geological mapping program along the southeast contact aureole of the Pokiok Batholith. Other projects of this type are planned to encourage utilization of geochemical data collected by various mining companies and the Geological Surveys Branch.

OTHER ACTIVITIES

M.J. McLeod and S.R. McCutcheon participated in the preparation of Decade of North American Geology (DNAG) publications for the Avalon Zone and Mascarene Belt. A.A. Ruitenberg contributed to DNAG by preparing overviews on granitoid related deposits and gold deposits in New Brunswick. He also provided summaries of base-metal deposits in southeastern New Brunswick.

M.J. McLeod and A.A. Ruitenberg cooperated with L.R. Fyffe in the preparation of the 1991 field-trip guidebook for the New England Intercollegiate Geological Conference (NEIGC) entitled: A Geotraverse Across

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[19]The Sussex Regional Office serves as an operational base for geoscience programs and geoscientific consulting services required by the mineral industry and the public in southern New Brunswick.

the St. Croix-Avalon Terrane Boundary, Southern New Brunswick. This guidebook will also be used for the 1992 Annual Meeting of the Geological Association of Canada in Wolfville, N.S.

M.J. McLeod, A.A. Ruitenberg, and T.E. Krogh prepared a paper entitled: A Previously Unrecognized Lower Ordovician Sequence in Southern New Brunswick: Evidence for Multistage Development of Iapetus, which was presented at the 1991 Annual Meeting of the Atlantic Geoscience Society in Amherst, Nova Scotia.

A.A. Ruitenberg and M.J. McLeod prepared a paper entitled: Metallogenic Implications of a Newly Discovered Ordovician Island Arc Sequence in Southern New Brunswick. This paper was presented at a special session on "Mineralization in the Grenville Province and the Appalachians", which constituted part of the program of the Annual Meeting of the Geological Association of Canada, in Toronto. A.A. Ruitenberg was also the chairperson for this session.

At the March meeting of the New Brunswick Branch of the Canadian Institute of Mining and Metallurgy in Fredericton, A.A. Ruitenberg presented a paper entitled Geology and Tectonic Setting of Some Precious Metal Deposits in Nevada and Idaho – Comparison with New Brunswick. This paper resulted from an extensive field trip in the southwestern United States during the fall of 1990.

A.A. Ruitenberg and L.R. Fyffe completed a report entitled: Characteristics and Tectonic Setting of Granitoid Related Mineral Deposits in New Brunswick, which was published as Geoscience Report 91-1.

M.J. McLeod and A.A. Ruitenberg conducted field examinations of several mineral properties held by various mining companies in southern New Brunswick. Consulting services were also provided for numerous exploration geologists, prospectors, engineers, foresters, and hydrologists.

A.A. Ruitenberg attended a field trip along Cunningham Brook, in the Nerepis area, with Dr. Susan Turner of the Queensland Museum, Australia. The occurrence of Thelodus parvidens scales in the Long R Formation was originally discovered by Matthews. These small, more or less square, fish scale fossi abundant in concretions that represent excrement from these large fish (in excess of 1 m long). In additi... Thelodus, Ceratiocaris fossils occur in these rocks. In 1839, Mercheson used Thelodus parvidens to define the Silurian system in the Welsh Borderlands, where these fossils range from Llandovery to Early Pridoli. In addition to Wales and New Brunswick, Thelodus parvidens occurs in Nova Scotia (Early Pridoli), South Norway (Late Llandovery-Ludlow), Southern Sweden (Ludlow-Early Pridoli), Gotland (Late Ludlow-Early Pridoli), Estonia (Late Ludlow), Northern Timar [U.S.S.R.] (Late Ludlow-Early Pridoli). Therefore, these fossils characterize the Silurian strata along the eastern margin of the Appalachian-Caledonian Mountain System. Another fish species, Longanellia Scotia occurs in the Armstrong Brook Formation [N.B.] (Late Llandovery), the La Vieille Formation [Québec, Western Ireland] (Late Llandovery), Scotland (Late Llandovery), and Siberia (Llandovery). Therefore, this species characterizes the Silurian strata along the western margin of the Appalachian-Caledonian Mountain System. The presence of these distinctly contrasting fish species in Silurian strata of northern and southern New Brunswick suggests that these areas were either separated by a major marine basin and/or landmass at least until Pridoli time.

A.A. Ruitenberg continued participation in a committee with the mandate to evaluate Mineral Exploration Stimulation Program (MESP) proposals. This program has resulted in the discovery of several economically significant mineral occurrences in southern New Brunswick in recent years. In cooperation with consulting geologist Gustaaf Kooiman, he also prepared a proposal for an indium investigation at Mount Pleasant, the objective being to establish the presence of an indium resource in that area. Computer chips made with indium phosphide are 225 times more efficient than conventional silicon chips.

A.A. Ruitenberg continued to provide geological advice for forest-site classification. It is encouraging to note that forest-site investigation is becoming increasingly important with the introduction of the single-arm harvesters for selective cutting and thinning. Other environment-related activities included the review and field checking of the hydrogeology of several sites proposed for regional waste disposal facilities in Kings and Westmorland/Albert Counties. Geological advice was also provided to water-well drillers upon request.

F.H. Kelly and M.J. Mazerolle continued to provide efficient support services to exploration geologists and prospectors. M.J. Mazerolle conducted claim inspections where problems occurred. Figures and maps were drafted for various publications and claim information was kept up-to-date on a computerized listing. About 33 000 feet of diamond-drill core was transported from the Lake George Antimony-Gold mine site to the Sussex core-storage facility.

ACTIVITÉS DU BUREAU RÉGIONAL DE SUSSEX

A. A. Ruitenberg
Géologue régional

En 1991, le personnel du bureau régional de Sussex était composé de Arie A. Ruitenberg (géologue régional), Malcolm McLeod (géologue adjoint régional), Maurice Mazerolle (technicien en génie civil et inspecteur des claims) et Freda Kelly (agente des services administratifs). Alain Caron et Susan Johnson ont été employés en vertu de l'Entente de coopération Canada/Nouveau-Brunswick sur l'exploitation minérale (EEM). David Rose a terminé en mars son engagement contractuel MDA et il a continué à travailler sur le terrain grâce à des fonds de la province. Le personnel estival itinérant était composé de Kenneth Jones, Jeffrey Earle, Micheline Luscombe et de Jason Ross.

PROGRAMMES ET PROJETS

M.J. McLeod et A.A. Ruitenberg ont continué à vérifier sur place les zones problématiques dans les parties de 21 G et de 21 H. Au retour de son congé de maternité, en août, Susan Johnson a poursuivi les travaux de compilation des cartes géologiques. Trois cartes géologiques à l'échelle de 1/50 000, 90-152, 90-153 et 90-154 (21 G/9, 21 H/12 et H/13), ont été vérifiées sur le terrain et ont été compilées. Une carte géologique métallogénique préliminaire de 21 G à l'échelle de 1/250 000 a également été préparée. Les travaux sur le terrain ont principalement été axés sur la corrélation régionale des formations géologiques de St. Croix et d'Avalon, dans le sud-ouest de la province, et sur la délimitation des zones minéralisées ayant une certaine importance économique. Les travaux sur le terrain ont été complétés par un programme de détermination de l'âge de l'U-Pb entrepris en collaboration avec T.E. Krogh, du Royal Ontario Museum, à Toronto.

A. Caron et K. Jones ont entrepris des travaux de cartographie de la géologie et des nombreux gîtes minéraux associés aux zones de skarns longeant l'auréole de métamorphisme du batholite de Pokiok jusqu'au sud-ouest et au nord-est du gisement d'antimoine-or de Lake George. Les relations entre les filons, les altérations rocheuses connexes et les structures des diverses zones de skarns ont été mises en relief. On est en train d'intégrer cette information aux données géologiques obtenues l'an dernier grâce aux travaux de cartographie souterraine entrepris au gisement de Lake George ainsi qu'au prélèvement de carottes de sondage. Les données obtenues sur place seront également mises en corrélation avec les cartes détaillées électromagnétiques TBF et celles obtenues par gradiomètre magnétique aéroporté réalisées sous la direction de la Commission géologique du Canada, au cours de l'été et de l'automne 1991.

D.G. Rose a localisé et défini plusieurs gîtes minéraux supplémentaires couverts par les feuilles topographiques 21 G et 21 H à l'échelle de 1/250 000. Des échantillons ont été prélevés à l'aide d'une scie à lame diamantée, et des matériaux minéralisés représentatifs ont été envoyés en vue d'en évaluer la teneur. Les résultats de l'enquête ont servi à mettre à jour le fichier électronique des gîtes minéraux.

J.M. Mazerolle, avec la coopération de Paul Rennick, a dirigé des travaux de modélisation électronique des données géochimiques relatives aux sédiments fluviatiles de 21 G/14 E en vue de compléter le programme de cartographie géologique le long de l'auréole de métamorphisme du batholite de Pokiok. D'autres projets de ce type sont prévus afin d'encourager l'utilisation des données géochimiques recueillies par diverses sociétés minières et la Direction des études géologiques.

AUTRES ACTIVITÉS

M.J. McLeod et S.R. McCutcheon ont participé à la préparation des publications Decade of North American Geology (DNAG) pour la région d'Avalon et la ceinture de Mascarene. A.A. Ruitenberg a participé à la préparation de DNAG en préparant des aperçus sur des gisements granitoïdes et des gisements aurifères du Nouveau-Brunswick. Il a également fourni de sommaires sur les gisements de métaux communs du sud-est du Nouveau-Brunswick.

M.J. McLeod et A.A. Ruitenberg ont collaboré avec L. R. Fyffe à la préparation du guide d'excursions sur le terrain de 1991, à l'intention de la New England Intercollegiate Geological Conference (NEIGC), intitulé «A Geotraverse Across the St.Croix-Avalon Terrane Boundary», dans le sud du Nouveau-Brunswick. Ce guide sera également utilisé au cours de la réunion annuelle de 1992 de l'Association géologique du Canada, qui doit se tenir à Wolfville, N.-É.

M.J. McLeod, A.A. Ruitenberg et T.E. Krogh ont préparé un document intitulé «A Previously Unrecognized Lower Ordovician Sequence in Southern New Brunswick: Evidence for Multistage Development of Iapetus», qui a été présenté lors de la réunion annuelle de 1991 de l'Atlantic Geoscience Society, à Amherst, Nouvelle-Écosse.

A.A. Ruitenberg et M.J. McLeod ont préparé un document intitulé «Metallogenic Implications of a Newly Discovered Ordovician Island Arc Sequence in Southern New Brunswick». Le document a été présenté à l'occasion d'une séance spéciale intitulée «Mineralization in the Grenville Province and the Appalachians», qui faisait partie du programme de la réunion annuelle de l'Association géologique du Canada tenue à Toronto. A.A. Ruitenberg a également présidé cette séance.

Lors de la réunion de mars de la section néo-brunswickoise de l'Institut canadien des mines et de la métallurgie, tenue à Fredericton, A.A. Ruitenberg a présenté un document intitulé «Geology and Tectonic Setting of some Precious Metal Deposits in Nevada and Idaho - Comparison with New Brunswick». Ce document est le fruit d'une exploration considérable du sud-est des États-Unis, entreprise au cours de l'automne 1990.

A.A. Ruitenberg et L.R. Fyffe ont terminé un rapport intitulé «Characteristics and Tectonic Setting of Granitoid Related Mineral Deposits in New Brunswick», et publié sous le nom de «Geoscience Report 91-1».

M.J. McLeod et A.A. Ruitenberg ont dirigé sur le terrain les examens de plusieurs propriétés minières tenues par diverses sociétés minières dans le sud du Nouveau-Brunswick. Des services de consultation ont également été fournis à un grand nombre de géologues prospecteurs, de prospecteurs, d'ingénieurs, de forestiers et d'hydrologues.

A.A. Ruitenberg a participé à une excursion sur le terrain le long du ruisseau Cunningham dans la région de Nerepis, avec Susan Turner, du Queensland Museum, en Australie. Le gisement d'écailles de Thelodus parvidens de la formation de Long Reach a été au départ découvert par Matthews. Ces fossiles de petites écailles de poissons, plus ou moins carrées, sont abondants dans des concrétions représentant des excréments de ces énormes poissons (de plus d'un mètre de longueur). Outre le thelodus, ces roches contiennent des fossiles de Ceratiocaris. En 1839, Mercheson a utilisé le thelodus parvidens pour définir le système silurien dans les blocs enfoncés gallois, où ces fossiles s'échelonnent du Llandovérien au Pridoli inférieur. Outre le pays de Galles et le Nouveau-Brunswick, le thelodus parvidens se trouve en Nouvelle-Écosse (Pridoli inférieur), dans le sud de la Norvège (Llandovérien supérieur-Ludlow), dans le sud de la Suède (Ludlow-Pridoli inférieur), dans le Gotland (Ludlow supérieur-Pridoli inférieur), en Estonie (Ludlow supérieur), dans le nord du Timar, en URSS, (Ludlow supérieur-Pridoli inférieur). Ces fossiles caractérisent par conséquent la strate silurienne qui longe la bordure orientale du système Appalaches-Calédonie. Une autre espèce de poisson, la Longanellia Scotia se rencontre dans la formation du ruisseau Armstrong, au Nouveau-Brunswick (Llandovérien supérieur), dans la Vieille Formation (Québec, ouest de l'Irlande) (Llandovérien supérieur), en Écosse (Llandovérien supérieur) et en Sibérie (Llandovérien). Ces espèces caractérisent par conséquent la strate silurienne qui longe la bordure occidentale du système Appalaches-Calédonie. La présence de ces espèces de poissons, distinctement contrastantes dans la strate silurienne du nord et du sud du Nouveau-

Brunswick, laisse supposer que ces régions étaient séparées, soit par un immense bassin marin, soit par une masse continentale, au moins jusqu'au Pridoli.

A.A. Ruitenberg a continué à participer à un comité ayant pour mandat d'évaluer les propositions du Programme de stimulation de la prospection minière (PSEM)] [Mineral Exploration Stimulation Program (MESP)]. Ce programme a abouti à la découverte, ces dernières années, dans le sud du Nouveau-Brunswick, de plusieurs gîtes minéraux importants du point de vue économique. En collaboration avec le géologue-conseil Gustaaf Kooiman, il a également préparé une proposition en vue d'étudier l'indium au mont Pleasant, afin d'établir la présence d'une ressource d'indium dans cette région. Les puces électroniques faites de phosphure d'indium sont 225 fois plus efficaces que les puces de silicium conventionnelles.

A.A. Ruitenberg a continué à donner des conseils géologiques pour la classification des sites forestiers. Il est encourageant de constater que les études menées sur les sites forestiers deviennent de plus en plus importantes avec l'introduction de la moissonneuse à bras unique pour la coupe de jardinage et l'éclaircissage. Les autres activités reliées à l'environnement ont compris l'étude et la vérification sur le terrain de l'hydrologie de plusieurs emplacements envisagés pour l'aménagement de dépotoirs dans les comtés de Kings et de Westmorland/Albert. Des conseils géologiques ont également été donnés sur demande à des foreurs de puits artésiens.

F.H. Kelly et M.J. Mazerolle ont continué à offrir des services de soutien efficaces aux géologues prospecteurs et aux prospecteurs. M.J. Mazerolle a mené des inspections de claims aux endroits où des problèmes se posaient. Des diagrammes et des cartes ont été dessinés pour diverses publications, et l'information sur les claims a été tenue à jour sur une liste informatisée. Environ 33 000 pieds de carottes de sondage ont été transportés du site minier d'antimoine-or de Lake George à l'entrepôt de stockage des carottes de Sussex.

COMPILATION AND CORRELATION OF SOUTHWESTERN NEW BRUNSWICK GEOLOGY; CHARLOTTE, QUEENS, KINGS, SAINT JOHN, AND SUNBURY COUNTIES (PROV & C-NBCAMD)[20]

Malcolm J. McLeod, Arie A. Ruitenberg, and Susan C. Johnson
Sussex Regional Office

Field checking for the geological compilation and correlation project in southwestern New Brunswick was conducted in problem areas that constitute parts of 1:250 000 map sheets 21 G and 21 B. The emphasis was placed on Cambrian rocks of the Avalon Terrane and Silurian rocks of the Mascarene Cover Sequence in the Mascarene, Beaver Harbour, and Deer Island areas. Ordovician and Silurian formations in the South Oromocto Lake area were also delineated. Most interesting economically was the recognition of Cambrian rocks southwest of Beaver Harbour and on small islands east of Deer Island, and the extension of rocks of probable Cambrian age along the northwest margin of the Kingston Peninsula. Stratiform copper-silver deposits and occurrences are associated with Cambrian mafic-felsic pyroclastic sequences in the Beaver Harbour area and the islands to the southwest. There is also a possibility for similar deposits in the Long Reach area to the northeast.

On a entrepris la vérification sur le terrain au titre du projet de compilation et de corrélation géologiques dans le sud-ouest du Nouveau-Brunswick dans les zones problématiques qui font partie intégrante des feuilles topographiques 21 G et 21 B à l'échelle de 1/250 000. La vérification a été axée sur les roches cambriennes de la formation géologique d'Avalon et sur les roches siluriennes de la paragenèse de couverture de Mascarene dans les régions de Mascarene, de Beaver Harbour et de Deer Island. Les formations ordoviciennes et siluriennes au sud du lac Oromocto ont également été délimitées. Le fait le plus intéressant du point de vue économique a été la reconnaissance des roches cambriennes du sud-est de Beaver Harbour et des petites îles à l'est de Deer Island, ainsi que le prolongement des roches, probablement du Cambrien, longeant la bordure nord-ouest de la péninsule de Kingston. Les gisements et les gîtes stratiformes de cuivre-argent sont associés aux paragenèses pyroclastiques mafiques-felsiques du Cambrien dans la région de Beaver Harbour et dans les îles du sud-ouest. Il existe également une possibilité de gisements similaires dans la région de Long Reach jusqu'au nord-est.

The objectives of 1991 field work were to determine the extent and nature of Cambrian rocks of the Avalon Terrane and Silurian rocks of the Mascarene Cover Sequence in the Mascarene, Beaver Harbour, and Deer Island areas, and to delineate and correlate formations in the St. Croix Terrane near South Oromocto Lake.

To date, work on the geological compilation and correlation project for southwestern New Brunswick has resulted in preparation of preliminary maps at a scale of 1:50 000 for most of 21 G, 21 H, and 21 B (not published); production of maps at a scale of 1:50 000 for parts of 21 G and 21 H (published); and field investigations in the western part of 21 H, the northern part of 21 B, and most of 21 G. It is anticipated that additional maps at a scale of 1:50 000 for most of 21 G and 21 B, and part of 21 H, will be published before the 1992 field season. Due to the magnitude of this project, numerous maps and reports were extensively utilized as reference material and are gratefully acknowledged, if not directly quoted here.

During the post field season, emphasis was on problem areas in 21 G and 21 B (Figure 24). From an economic point of view, the most interesting discoveries were the recognition of Cambrian rocks to the southwest of Beaver Harbour and on small islands east of Deer Island, and the extension of rocks of probable Cambrian age in the Long Reach area along the northwest margin of the Kingston Peninsula (stippled unit, Figure 25). Mafic volcanic breccias, maroon felsic tuffaceous rocks, and volcanogenic sedimentary rocks in the Beaver Harbour area and on the small islands host high-grade, stratiform copper-silver deposits. These deposits, and the possibility of similar deposits to the northeast in the Long Reach area, warrant further investigation.

During the 1990 field season, considerable effort was expended to trace the strike extent of the metal-rich Ordovician rocks of the St. Croix Terrane in 21 H (Unit OA, Figure 25). It was assumed that the northern

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[20]This is part of an on-going effort to determine the geological makeup of the Province, and to identify the geological terranes with the highest mineral resource potential.

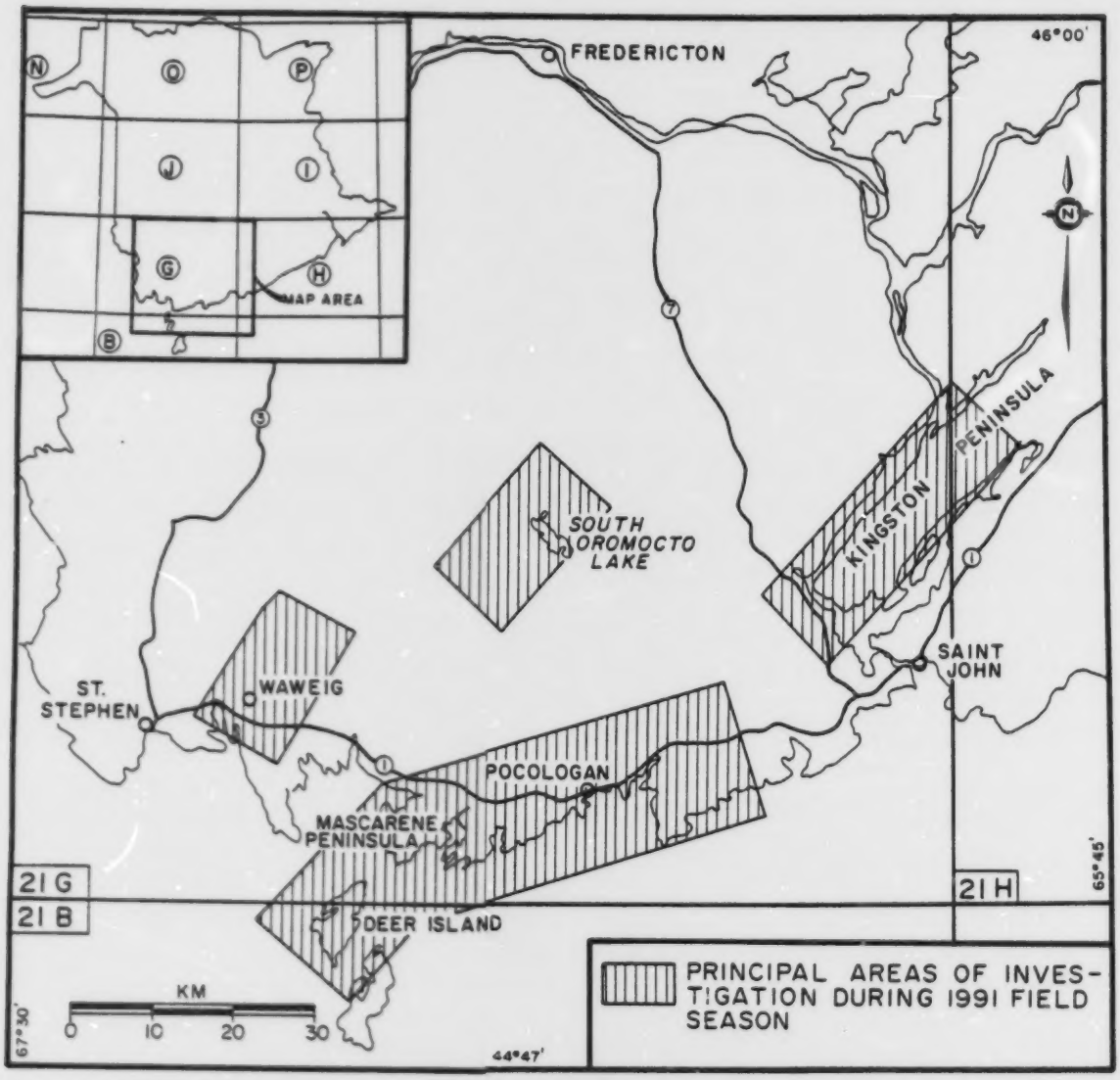


FIGURE 24. Areas of southwestern New Brunswick investigated during the 1991 field season.

boundary of these rocks, the Pendar Brook Fault, was equivalent to the Basswood Ridge Fault to the southwest, which was also thought to bound St. Croix Terrane rocks in that area to the north (Fyffe 1990*a*; McLeod *et al.* 1990). Recent investigations by the authors, in cooperation with L.R. Fyffe, have shown, however, that these faults are not equivalent and that the Pendar Brook Fault divides the St. Croix Terrane rocks into predominantly sedimentary and volcanic sequences, to the northwest and southeast, respectively. The stratigraphy of St. Croix Terrane rocks in the South Oromocto Lake area, northwest of the fault, has been successfully correlated with similar rocks to the southwest and subdivided into existing units (Digdeguash, Kendall Mountain, and Flume Ridge formations) and one new unit (Sand Brook Formation).

Mapping on Deer Island and on other smaller islands in the vicinity indicates that the area is underlain by an intensely deformed volcano-sedimentary sequence that is structurally and lithologically (in part) similar to the Silurian rocks in the northwestern part of the Mascarene Peninsula (Unit SM, Figure 25).

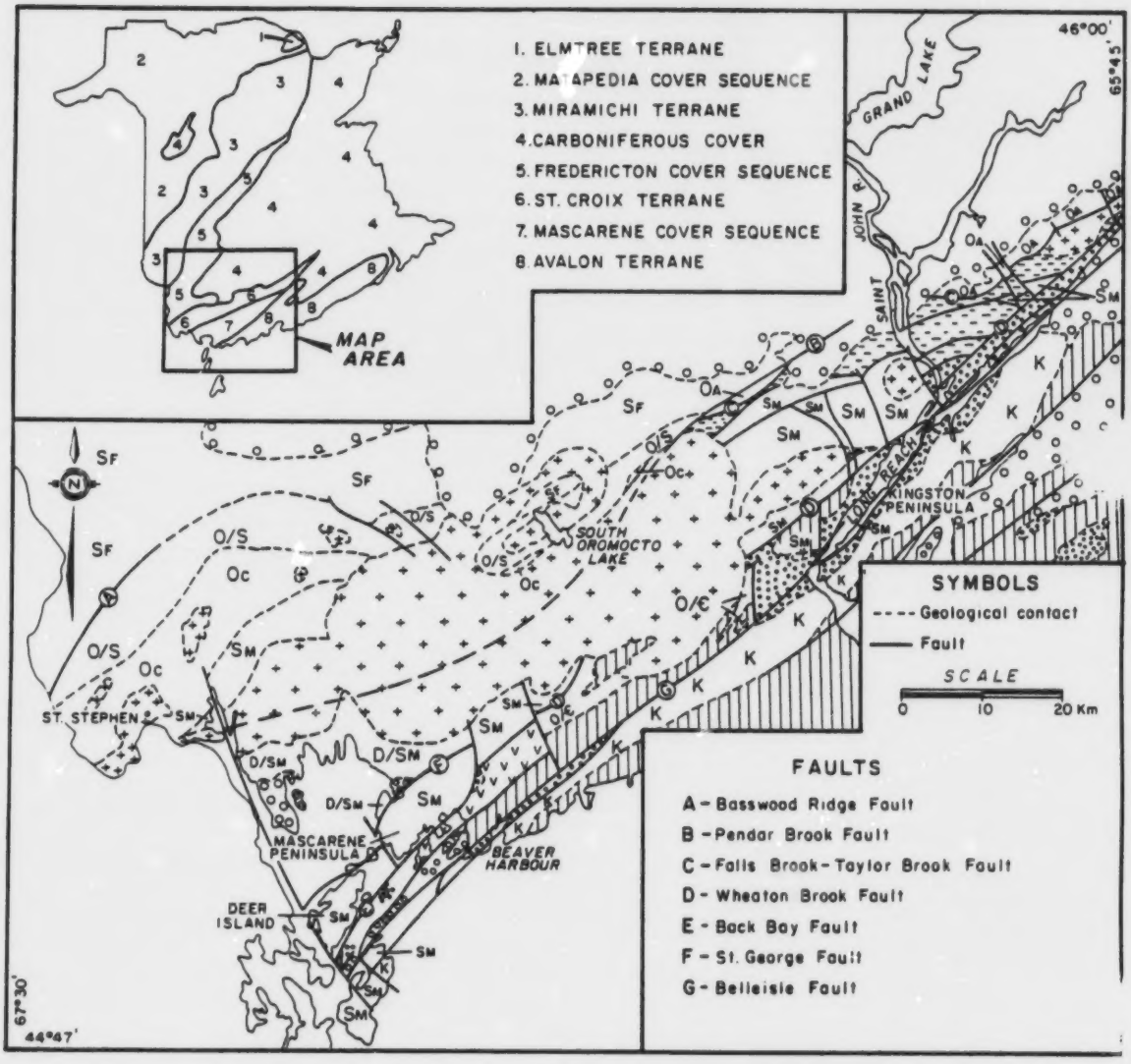
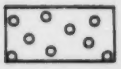


FIGURE 25. Generalized geology of southwestern New Brunswick.

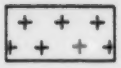
LEGEND

UPPER DEVONIAN AND CARBONIFEROUS

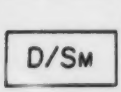


CARBONIFEROUS COVER
Sedimentary, and locally, volcanic rocks (Perry Fm., Horton Gp., Windsor Gp., Petitcodiac Fm., Piskahegan Gp., Beaver Harbour Gp.)

DEVONIAN AND SILURIAN

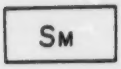


Granitoid and gabbroic intrusions



MASCARENE COVER SEQUENCE
Volcanic and sedimentary rocks (Eastport Fm.)

SILURIAN

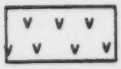


MASCARENE COVER SEQUENCE
Sedimentary and volcanic rocks (Jones Creek Fm., Long Reach Fm., Waweig Fm., Quoddy Fm., Letete beds, Henderson Brook beds)

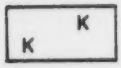
FREDERICTON COVER SEQUENCE
Sedimentary rocks (Flume Ridge Fm., Sand Brook Fm.)

SILURIAN AND OLDER

MASCARENE COVER SEQUENCE AND AVALON TERRANE

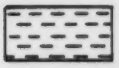


Felsic porphyry, and volcanic and sedimentary rocks (Mascarene); volcanic and granitoid rocks (Avalon). (Back Bay Fm., Goss Point beds, Letang volcanics)

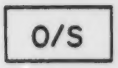


Felsic and mafic dykes; minor volcanic and granitoid rocks (Kingston Dyke Swarm)

ORDOVICIAN AND/OR SILURIAN

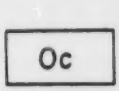


ST. CROIX TERRANE OR MASCARENE COVER SEQUENCE(?)
Sedimentary and minor volcanic rocks (Queens Brook Fm.)

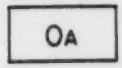


ST. CROIX TERRANE
Sedimentary rocks (Digdeguash Fm.)

ORDOVICIAN

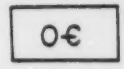


ST. CROIX TERRANE
Sedimentary and minor volcanic rocks (Kendall Mountain Fm., Woodland Fm., Calais Fm.)



Volcanic and sedimentary rocks (Lawson Brook Fm., East Scotch Settlement Fm.)

ORDOVICIAN AND CAMBRIAN



AVALON TERRANE
Volcanic and sedimentary rocks; minor granitoid and gabbro intrusions (Fowle Lake beds)

CAMBRIAN AND POSSIBLE UPPER HADRYNIAN

AVALON TERRANE
Sedimentary and volcanic rocks (Saint John Gp., Buckmans Creek beds)

PRECAMBRIAN AND LOWER CAMBRIAN

AVALON TERRANE
Granitoid and minor mafic intrusive rocks, volcanic rocks, sedimentary rocks and gneiss (Coldbrook Gp., Greenhead Gp.)

A unit of intensely silicified and carbonatized felsic volcanic breccias and tuffaceous rocks hosting stratabound sulphide mineralization crops out near the western shore of Deer Island. The economic potential of this unit, which passes gradationally into mostly unmineralized felsic to intermediate crystal tuffs along strike, remains untested. Previously unrecognized volcanic rocks, equivalent to those northwest of the Mascarene Peninsula (Unit D/SM), also occur in the vicinity of Deer Island and are separated from Unit SM by the Saint George Fault as on the mainland.

A U-Pb dating program, which constitutes an integral part of this project, was initiated to confirm proposed correlations within southern New Brunswick and to enhance the economic potential of specific belts of rocks. All dates were supplied by Dr. T.E. Krogh of the Royal Ontario Museum in Toronto and are quoted below from written communications.

Dates (circa 492 Ma) from an intensely deformed felsic volcanic unit and from a black rhyolite dome near Annidale, indicate that all pre-Carboniferous rocks between the Falls Brook-Taylor Brook Fault and the Pendar Brook Fault (Fyffe 1990*b*; McLeod *et al.* 1990) are Lower Ordovician in age (McLeod *et al.* 1991). Analyses of samples from a similar black rhyolite dome at the Harborside base-metal deposit in Maine, which occurs about 280 km to the southwest of Annidale along strike, also yields a Lower Ordovician age circa 500 Ma. Calahan Mining operated an open-pit mine at the Harborside deposit between 1966 and 1972. This implies that similar stratiform base-metal deposits could be present in the Ordovician rocks of southwestern New Brunswick. The Annidale Belt of New Brunswick, which hosts several vein-type and stratiform base-metal occurrences in addition to gold, clearly warrants further investigation for stratiform base-metal deposits (Ruitenberg and McLeod 1991).

One date (Late Silurian) from the granodiorite intrusion immediately underlying the Lake George antimony-gold deposit, verifies that the intrusion is related to emplacement of the large Pokiok Batholith loc: 4 km to the northwest (*cf.*, Bevier and Whalen 1990). This reinforces the probability that major deposits, simi.. to those at Lake George, could occur in the contact aureole of the batholith.

Samples taken from deformed rhyolitic rocks in the "Letang Volcanics" (Figure 25) yield a Cambrian date circa 550 Ma. This date approximates the age assigned to this unit by Currie (1988) and partially confirms his interpretation. Although the aerial extent of Cambrian rocks in this area is considerably expanded, it is notable that part of this volcanic sequence is Silurian or younger since rhyolitic dykes intrude fossiliferous Silurian strata.

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LAKE GEORGE ANTIMONY-GOLD PROJECT, NEW BRUNSWICK (C-NBCAMD)[21]

A. Caron
Project Geologist

The objective of the Lake George antimony-gold project is to establish the relationships of various mineral deposits and occurrences to rock alteration and structural evolution of skarn zones in the southeastern contact aureole of the Pokiok Batholith. The host rocks of the mineralized skarns are closely to tightly folded, Silurian greywackes and slates. This year's work was concentrated on skarn zones to the northeast and southwest of the Lake George antimony-gold deposit. The metallic mineral occurrences in these skarn zones include those characterized by: scheelite, molybdenite, and gold; arsenopyrite and gold; stibnite and native antimony; and locally, uranium minerals. Detailed structural investigations during the summer established that the various types of mineral occurrences were emplaced late to post the main skarn development.

L'étude sur l'antimoine-or de Lake George vise à établir les relations entre divers gisements et gîtes minéraux avec l'altération rocheuse et l'évolution structurale des zones de skarns dans l'auréole de métamorphisme sud-est du batholite de Pokiok. Les roches hôtes des skarns minéralisés sont des grauwackes et des schistes ardoisiers siluriens, étroitement à hermétiquement plissés. Les travaux de cette année ont essentiellement porté sur les zones de skarns jusqu'au nord-est et au sud-ouest du gisement d'antimoine-or de Lake George. Les gîtes minéraux métalliques de ces zones de skarns comprennent ceux caractérisés par : la scheelite, la molybdénite et l'or; l'arsénopyrite et l'or; la stibnite et l'antimoine naturel; et localement, les minéraux d'uranium. Des études structurales détaillées entreprises au cours de l'été ont établi que les divers types de gîtes minéraux ont été tardivement enchâssés pour soutenir le complexe principal de skarns.

Several types of mineral deposits and occurrences are found within the southeastern contact aureole of the Siluro-Devonian Pokiok Batholith granodiorite intrusion. The Lake George antimony-gold deposit is the largest known deposit in this area, but there are also numerous metallic mineral occurrences of economic interest to the northeast and southwest of the mine site. The purpose of the present investigation is to provide a reliable guide for mineral exploration by establishing the relationships of the various mineral occurrences to rock alteration and the structural evolution of the contact aureole. Last year's work was confined to the Lake George mine site itself, whereas this year's investigation was concentrated on the areas to the northeast and southwest of the mine in parts of map sheets 21 G/11, 14, 15; and 21 J/2, 3 (Figure 26).

The host rocks of the mineral occurrences are closely to tightly folded, micaceous and calcareous, Silurian greywackes and siltstones. Bedding thicknesses vary from 10 to 50 cm in the greywackes and commonly less than 10 cm in the siltstones. Typical Bouma sequences have been recognized locally. The axial surfaces of the folds generally strike north-northeast and dip steeply. The fold axes plunge shallowly to steeply to the north or south. A slaty cleavage is well-developed in the siltstones parallel to the axial surfaces. A typical solution cleavage is characteristic of the greywacke beds. Close to the granodiorite contact, the solution cleavage grades into a differentiated cleavage defined by mica- and quartz-rich layers. Although sedimentary structures can still be recognized in some localities, most of the greywacke-siltstone sequences are metamorphosed to biotite-andalusite-cordierite- and sillimanite-bearing hornfels.

Several different types of mineral deposits and occurrences are found associated with skarn zones in the southeastern contact aureole of the Pokiok Batholith and associated small stocks. The metallic mineral assemblages distinguished in these skarn zones include those characterized by scheelite, molybdenite, and gold; arsenopyrite and gold; stibnite and native antimony; and locally, uranium minerals. These mineral assemblages occur as disseminations and pods, and are associated with quartz ± carbonate veins.

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[21]Contribution to the Canada - New Brunswick Cooperation Agreement on Mineral Development, 1990-95. Project carried by the Geological Surveys Branch of the New Brunswick Department of Natural Resources and Energy. The region being studied has always been considered prime prospecting ground for antimony, gold, and copper deposits. This investigation is aimed at providing targets for detailed exploration for new deposits of the above metals.

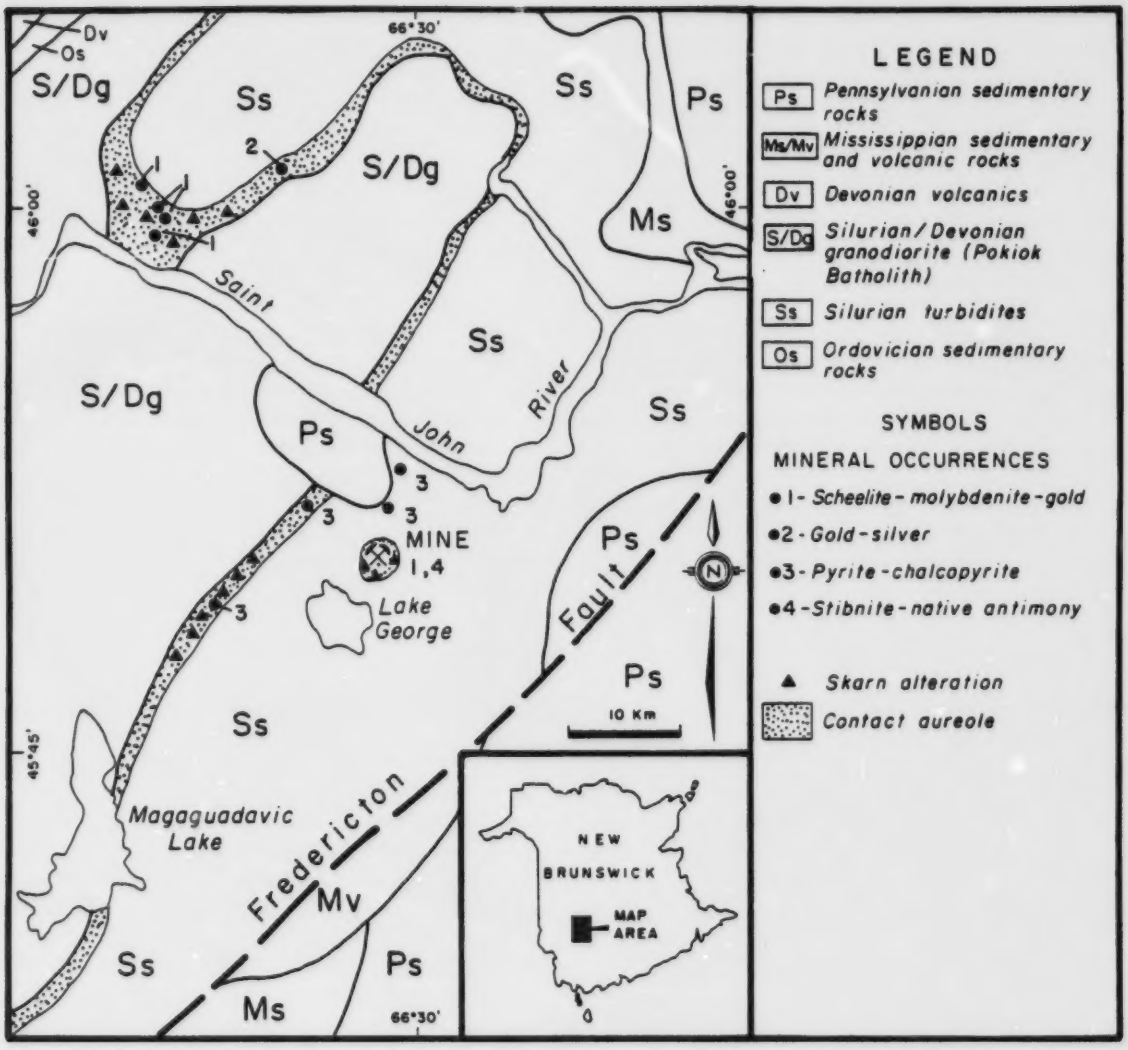

FIGURE 26. Generalized geology of the Lake George antimony-gold project area: McAdam (21 G/11); Canterbury (21 G/14); Fredericton (21 G/15); Burtts Corner (21 J/2); and Millville (21 J/3).

Detailed structural investigations during the summer have shown that emplacement of the various metallic mineral assemblages occurred late in the development of the main skarn. The earliest skarn development, prior to emplacement of the metallic minerals, was clearly controlled by structure and stratigraphy. Carbonate-rich veining associated with the early skarn development is, in some beds, confined to well-developed solution cleavage surfaces. In other places, entire beds are replaced by actinolite, quartz, epidote, and locally, diopside. In these beds, metamorphic fluids appear to have moved along both the solution cleavage and parallel- to thin-folded beds. The metallic mineral-bearing, quartz-carbonate veins strike mostly east-west or northerly and clearly cut across the early phases of skarn development.

The earliest veins in the Lake George deposit are scheelite-molybdenite- and gold-bearing quartz-carbonate veins. The most recently delineated auriferous oreshoot in the mine consists of a steeply plunging, carbonatized, silicified, and sericitized stockwork zone. The stockwork contains bismuthinite, arsenopyrite, and gold that occur along fractures and as disseminations (Ruitenberg *et al.* 1990). Stibnite and native antimony

occur as irregular-shaped lenses and veins that are mainly concentrated in gently northeast-striking flexures in the north-dipping Hibbard vein. The flexures occur where the veins cut across competent beds in the vicinity of regional fold hinges (Morrissy and Ruitenberg 1980). The antimony-bearing veins cut across the gold-bearing structures where the relationship could be established.

Scheelite-molybdenite-gold-bearing quartz-carbonate veins, similar to those found at the Lake George deposit, are exposed locally in the northeastern part of the project area near Coac Stream. These veins strike approximately east-west or north-northeast, dip steeply, and are roughly parallel to the differentiated cleavage. Other interesting occurrences in this area are east-striking and steep-dipping siliceous breccia zones that contain arsenopyrite, pyrite, chalcopyrite, and gold. Pyrite- and chalcopyrite-bearing fracture zones have also been found northwest of the Lake George deposit. Representative samples of this mineralized material have been submitted for gold assaying, but no results were available at the time of writing this report.

Although undoubtedly present, stibnite- and native-antimony-bearing veins have not been found in surface exposures in the project area. Veins containing antimony minerals are probably not exposed, because they are enveloped by thick sericitic alteration zones that offer little or no resistance to glacial and/or fluviatile erosion. Moreover, a relatively high proportion of the project area is covered by poorly drained glacial till. It is expected, however, that skarn zones and major structures that are only partly exposed can be delineated with the assistance of airborne magnetic gradiometer and VLF-EM maps, which are being prepared under the auspices of the Geological Survey of Canada. Till geochemical maps in preparation by the New Brunswick Geological Surveys Branch and geochemical stream-sediment data from various mining companies and compiled in a computerized format by M.J. Mazerolle will also assist in evaluating the mineral potential of the project area.

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NEW BRUNSWICK COMPUTERIZED MINERAL OCCURRENCE DATABASE (C-NBCAMD & PROV)[22]

D.G. Rose
Project Geologist

During the 1991 field season, David Rose assisted by Jason Ross, located, examined, and sampled mineral occurrences in parts of 21 G and 21 H. Most important was to document the mineral occurrences in the Ordovician volcanic and sedimentary rocks in the Annidale Belt. This belt contains numerous gold occurrences of economic interest and has potential for stratiform sulphide deposits.

The descriptions of the occurrences visited were incorporated into the New Brunswick Computerized Mineral Occurrence Database. Any final corrections in the file were made at this time. Descriptions and locations of occurrences visited over the last two years were prepared and will be compiled in a final report. A sample suite of these occurrences is stored at the Sussex Office. Starting this fall, William Gardiner has agreed to add new occurrences to the computerized file. Updated disks will be retained in the Fredericton, Bathurst, and Sussex offices.

BANQUE DE DONNÉES INFORMATISÉE DES GÎTES MINÉRAUX DU NOUVEAU-BRUNSWICK (ECCNBEM & PROV)

D.G. Rose
géologue de projet

Au cours de la saison d'étude sur le terrain de 1991, David Rose a localisé, examiné et échantillonné, avec l'aide de Jason Ross, les gîtes minéraux des parties 21 G et 21 H. La tâche la plus importante a consisté à documenter la présence de minéraux dans les roches volcaniques et sédimentaires ordoviciennes de la ceinture d'Annidale. Cette ceinture renferme un nombre important de venues aurifères revêtant un intérêt économique, et elle pourrait contenir des gisements de sulfure stratiforme.

Les descriptions des venues visitées ont été intégrées à la base de données informatisée des gîtes minéraux du Nouveau-Brunswick. Toutes les corrections finales au fichier ont été apportées à ce moment-là. Les descriptions et les emplacements des gîtes visités au cours des deux dernières années ont été préparés et seront compilés dans le rapport final. Une série d'échantillons de ces gîtes est stockée au bureau de Sussex. William Gardiner a accepté d'ajouter, à compter de cet automne, de nouveaux gîtes au fichier informatisé. On conservera des disques à jour aux bureaux de Fredericton, de Bathurst et de Sussex.

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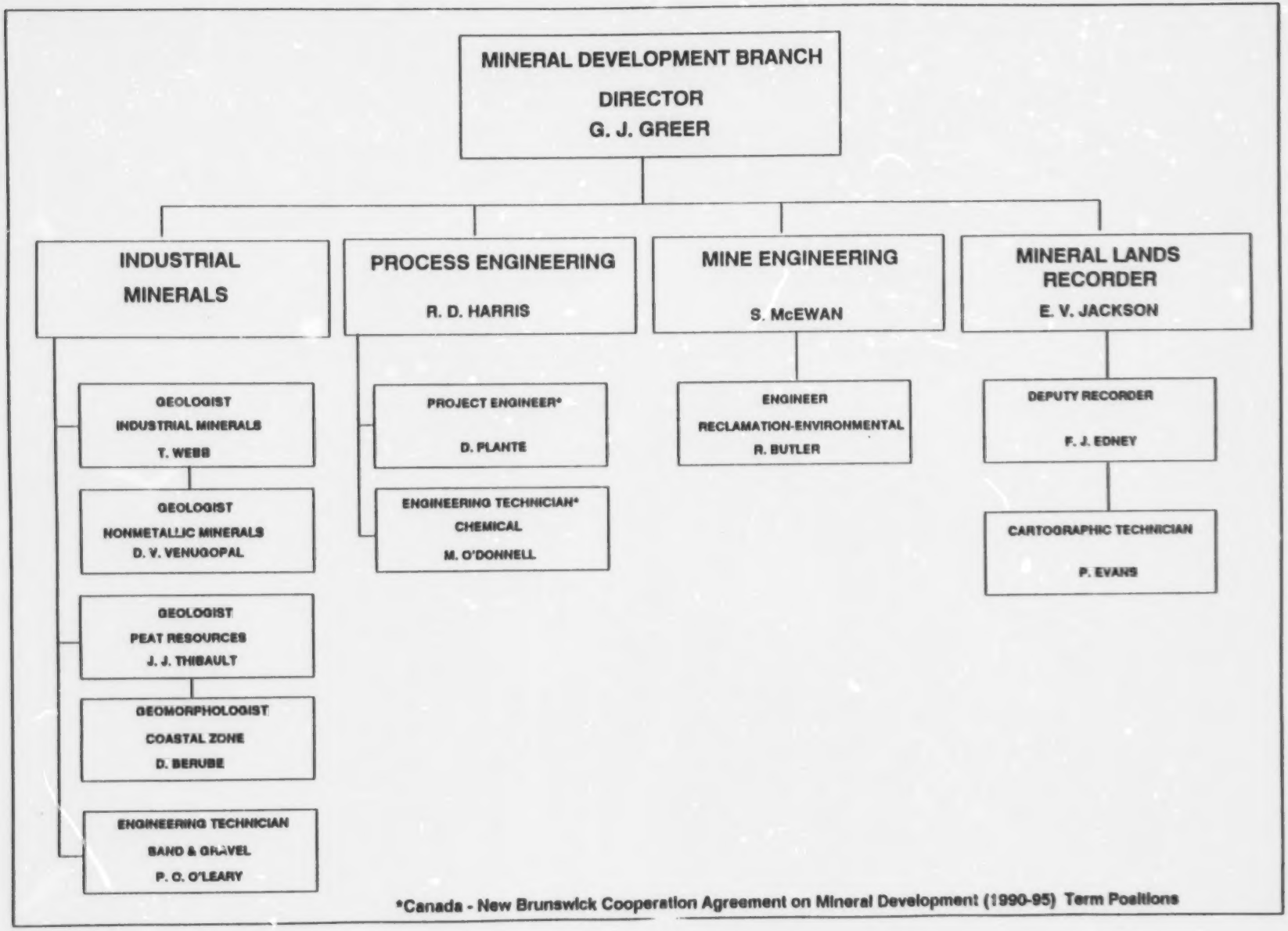
[22]This project, funded with both C-NBCAMD and Provincial monies, is part of the on-going documentation of mineral occurrences, and the buildup of the Province's mineral inventory. Such work is important for effective mineral resource exploration.

NOTES

MINERAL DEVELOPMENT BRANCH



Organization chart for Mineral Development Branch

MINERAL DEVELOPMENT BRANCH

INDUSTRIAL MINERALS SECTION

ORDOVICIAN-SILURIAN LIMESTONE RESOURCES OF NEW BRUNSWICK[23]

Tim C. Webb
Industrial Minerals Geologist

and

D.V. Venugopal
Nonmetallic Minerals Geologist

Limestone is one of the most useful and versatile industrial minerals produced in New Brunswick. Almost a million tonnes is quarried annually for various agricultural, construction, and chemical applications. Physical and chemical specifications for limestone-based products are becoming more stringent and end-use applications are expanding, particularly into the realm of pollution control. Although limestone is abundant in the Province, the supply of high-quality stone, particularly high-calcium varieties, is surprisingly limited.

Significant deposits of limestone and dolomite in Ordovician and Silurian rocks occur in the northern and northwestern parts of the Province. Others are found in west-central and southwestern New Brunswick.

Ordovician and Silurian limestone and related calcareous rocks rarely attain a grade and extent where they could be developed on a commercial scale. Although high-quality limestone is known to exist locally in rocks of reefal origin, their distribution is somewhat erratic. The most favourable regions to explore for such deposits is along a narrow belt of Silurian-Devonian strata extending southwest from Petit Rocher on the Bay of Chaleur to the Becaguimec River area, near Woodstock and in an area underlain by Ordovician-Silurian strata south and east of Woodstock.

Le calcaire est un des minerais industriels les plus versatiles et les plus utiles produits au Nouveau-Brunswick. Tout près d'un million de tonnes sont produites annuellement pour les industries de l'agriculture, de la construction et des applications chimiques. Les spécifications physiques et chimiques deviennent toutefois de plus en plus complexes à mesure que les possibilités d'utilisation se multiplient, principalement dans le domaine de la lutte contre la pollution. Bien que le calcaire abonde partout au Nouveau-Brunswick, la quantité de pierre de haute qualité est relativement restreinte, surtout celle à haute teneur en calcium.

On retrouve d'importants dépôts de calcaire et de dolomite dans des formations de l'ordovicien et du silurien dans les régions du nord et de l'ouest de la province. On en retrouve également un certain nombre dans les régions du centre-ouest et du sud-ouest de la province.

Le calcaire ordovicien et silurien ainsi que la roche calcaire apparentée atteignent rarement une teneur et une importance suffisantes pour permettre une exploitation commerciale. Bien qu'on connaisse l'existence, à l'échelle locale, de pierre de qualité élevée provenant de formations d'origine corallienne, celle-ci est plutôt dispersée. Les endroits les plus favorables pour la prospection se situent le long de l'étroite bande de roche du silurio-dévonien qui s'étend au sud-ouest de Petit-Rocher dans la Baie des Chaleurs jusqu'aux environs de la rivière Becaguimec, près de Woodstock ainsi qu'au sud et à l'est de Woodstock, où l'on retrouve une formation de roche de l'ordovicio-silurien.

INTRODUCTION

Most of New Brunswick's major resource-based industries are dependent to some degree on a reliable, nearby supply of limestone, dolomite and/or their products. Limestone (lime), traditionally used as a soil conditioner and as a source of aggregate, has become an essential mineral commodity with a formidable list of industrial applications. Indeed, it is one of the most useful and versatile of all the industrial minerals produced in this province.

The importance of limestone to the Province is well documented. In the past, several deposits have

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[23]Versatility and uses of limestone and its products have been known to man for several centuries. Extensive Province-wide use of limestone in agricultural, construction, and chemical application has prompted the Mineral Resources Division to undertake an inventory and evaluation of Ordovician-Silurian limestone resources of New Brunswick.

provided many local farmers with a nearby, inexpensive source of agricultural lime. Extensive deposits at Havelock, straddling the boundary between Kings and Westmorland counties, have supplied two of New Brunswick's largest limestone manufacturing operations. Almost a million tonnes of limestone is quarried annually in the Province for various agricultural, construction and chemical applications.

Limestone is present in virtually every geological system in New Brunswick, but only in Carboniferous, Silurian (Ordovician), and Precambrian strata does it attain sufficient thicknesses and grades to be considered of some economic significance.

Physical and chemical specifications for limestone-based products are becoming more stringent and end-use applications are expanding, particularly into the realm of pollution control. Although limestones are relatively plentiful throughout much of New Brunswick, the supply of particular grades, such as high-grade calcium limestone, is surprisingly limited. Therefore, effective prospecting for undiscovered deposits and prudent management decisions affecting known deposits are becoming increasingly important. Exploration programs for limestone, have been undertaken both by government and private industry. Not only have these initiatives lead to the discovery of new deposits, but they have also contributed significantly to the evaluation of known deposits.

Over the last 25 years, significant developments within the Province's limestone industry have included the expansion of Havelock Lime Works Ltd. into the production of quick and hydrated lime, and the opening of quarries and the establishment of a processing facility near Elmtree in northern New Brunswick.

PURPOSE AND SCOPE

Since the 1965 publication of J.B. Hamilton's "Limestone in New Brunswick", there has been no concerted effort to update information on the Province's limestone resources. Information is currently scattered in various Mineral Resources files and reports, and in numerous mineral property assessment reports.

The primary objective of this project is to present information on significant deposits of limestone and dolomite occurring in Ordovician and Silurian rocks throughout New Brunswick. It is intended to be a handy compilation rather than a definitive work on these resources.

An assessment of the Province's more well known deposits should provide a starting point for those individuals or companies considering exploration and possible future development of limestone resources. Both published and unpublished information obtained from the Mineral Resources files over the last two decades have contributed to this report. Included are pertinent data on access, topographic and geologic settings (stratigraphy and structure), and a summary of related exploration or development undertaken on specific deposits. Although preliminary observations concerning grades, tonnages, and quarry opportunities are presented for most deposits (Appendix 1), it is important to realize that comments in this regard are based on broad generalizations and cannot be considered as completely reliable without more detailed evaluation.

Field investigations, completed during the summer of 1984, included extensive sampling and mapping of several major Ordovician and Silurian limestone belts and outcrop areas in Carleton, Gloucester, Madawaska, Restigouche, Victoria, and York counties. One small deposit situtated on the Bay of Fundy coast in Charlotte County was also examined.

Representative samples from most deposits have been catalogued and are stored in an easily accessible manner at the Fredericton Regional Office of Mineral Resources. Existing sample analyses from past investigations were compiled. Sample information (*i.e.*, location, description, available analysis, etc.) and relevant drill-hole data for most areas have also been compiled.

The final report (near completion) contains detailed descriptions of Ordovician and Silurian limestone should acquaint the reader with many aspects of each deposit or occurrence. Some of the more significant deposits have been mapped at a scale of 1:10 000 (Figure 27).

■ Map areas:

1. Letang Peninsula - Frye Island (Plate 89-252)
2. Dorrington Hill (Plate 89-253)
3. Central Waterville (Plate 89-254)
4. Peel (Plate 89-255)
5. Ashland (Plate 89-256)
6. Carlisle (Plate 89-257)
7. Windsor (Plate 89-258)
8. Salmon River (Plate 89-259)
9. Siegas (Plate 89-260)
10. Upsalquitch Forks - S. Br. Charlo R.
11. Pointe Rochette
12. Black Point - Nash Creek (Plate 89-261)
13. Quinn Point - Culligan (Plate 89-262)
14. Belledune (Plate 89-263)
15. Elmtree - LaPlante (Plate 89-264)
16. S. Br. Millstream R. - Lower Tetagouche Lk. (Plate 89-265)
17. Lincour
18. Armstrong Brook - Tetagouche River

FIGURE 27. General distribution of Ordovician and Silurian limestone-bearing rocks (shaded) in New Brunswick, and mapped areas.

Ordovician and Silurian rocks are widely distributed throughout New Brunswick, underlying nearly 20% of the Province. Although limestone and related calcareous rocks are well represented in both systems, rarely do they attain a grade and extent where they could be commercially developed at the present time. Most of the more notable deposits occur in northern and northwestern New Brunswick. Smaller deposits are found in the west-central and southwestern part of the Province.

Ordovician-Silurian limestones can broadly be categorized into four groups, each separated aerially from each other, and each characterized by a particular lithologic assemblage. The first group occurs in the Baie des Chaleurs area where limestone-bearing rocks form an integral part of the Ordovician-Silurian stratigraphy of the region. The second group, located primarily in the northwestern part of the Province, is mostly associated with extensive Upper Ordovician-Silurian argillites belonging to the Carys Mills (Matapédia Group) and Siegas formations. A third group is situated in west-central New Brunswick, near Woodstock. Most limestone deposits in this area are largely associated with grey calcareous sandstones and siltstones of the Silurian age, Smyrna Mills Formation. A few Ordovician inliers, comprising argillaceous to crystalline limestone and referred to as the Craig Brook Limestone and the Belle Lake Slate, occur locally throughout the region. A slightly metamorphosed Silurian limestone belonging to the Hartin Formation is found at Dorrington Hill. The fourth group, located in the southwestern part of the Province, is associated with rocks of the Silurian age Mascarene Series. The sequence is characterized by a preponderance of volcanic rocks with minor sedimentary rocks that include limestone.

BAIE DES CHALEURS (Northern New Brunswick)

Notable Ordovician limestone deposits are not widespread in the Baie des Chaleurs area. A few occurrences southeast of Dalhousie are represented by thin, interbedded, argillaceous limestones and mudstones of the Matapedia Group, while other occurrences west of Bathurst are associated with an intensely deformed belt of Cambro-Ordovician volcanic and sedimentary rocks belonging to the Tetagouche Group. Limestone deposits in Tetagouche rocks are generally found interbedded with varying amounts of calcareous slate. Most Ordovician limestone deposits in the region are relatively impure.

Better quality limestone deposits of the Baies des Chaleurs region are associated with Lower to Middle Silurian strata. These rocks are found scattered along the coast between Campbellton and Beresford and in a few isolated inland exposures. Limestone-bearing rocks are stratigraphically distributed in three formations: the Limestone Point, the La Vieille, and Petit Rocher formations.

The Limestone Point Formation consists of a sequence of calcareous sandstone, frequently interbedded with irregular lenses of limestone. Although massive laminated, calcareous siltstones dominate the lithology of the La Vieille Formation, thick- to medium-bedded, highly fossiliferous, nodular limestone and silty limestone occur locally. A third assemblage of Silurian limestone in the area is represented by the Petit Rocher Formation. It comprises red, green, and grey calcareous shale and siltstone, and minor sandstone and contains remnants of Late Silurian carbonate reefs. These reefs and associated sediments are confined to a regional syncline, extending from Petit Rocher, 70 km to the southwest. Reefal limestones occur sporadically in outcrop and in small quarries along the strike length of this structure. Among the best exposures are those north of Upsalquitch Lake adjacent to the "Road to Resources"; near the eastern outlet of Lower Tetagouche Lake; west of Sormany; and at LaPlante and Elmtree. These deposits probably represent large allochthonous blocks of reefal material that have come to rest on, and are embedded in, basinal calcareous clastics (turbidites). They are significant in that they are among the highest quality limestone deposits found in Silurian strata in New Brunswick, and provide feed stock for northern New Brunswick's only limestone production facility, at Elmtree.

NORTHWESTERN NEW BRUNSWICK

Limestone resources of northwestern New Brunswick are, for the most part, associated with the sequence of Upper Ordovician to Lower Silurian strata, collectively referred to as the Matapedia Group. These rocks are spread over a considerable area, extending in a 50 km wide zone southwest of Campbellton to Grand Falls and then south to Woodstock, straddling the Canada-United States border. Similar to the Matapedia rocks in the Baie des Chaleurs region, their most salient feature is a monotonous lithology, in which hundreds of metres of grey, calcareous argillite, grey to black argillaceous limestone, and grey, crystalline limestone are thinly and regularly interbedded with one another. Typically, the thin, interbedded nature of the limestone and associated argillaceous material generally results in overall low grade deposits compared to other limestone occurrences throughout the Province. Even though higher grade deposits may occur locally, most yield low MgO values accompanied by CaO values seldom exceeding 35%. It is also important to note that these rocks have been folded and faulted to varying degrees which further complicate resource development.

WEST-CENTRAL NEW BRUNSWICK

Both Ordovician and Silurian limestones occur in relatively small scattered deposits in west-central New Brunswick. With few exceptions, most known deposits are situated northeast of Woodstock, within a 7 km radius of each other. Most tend to be associated with grey, calcareous sandstones and siltstone of the Silurian age Smyrna Mills Formation. A few inliers of Ordovician (*i.e.*, Craig Brook Limestone) argillite and associated argillaceous to siliceous limestone occur locally. East and south of Woodstock, limestone occurrences are represented by an Ordovician inlier at Central Waterville and a slightly metamorphosed deposit of Silurian age at Dorrington Hill.

Generally, limestone-bearing strata in this part of the Province is characterized by a relatively complex structural history. Intense folding and thrust faulting are reflected in moderate to steep dips and boudinage, resulting in somewhat small, isolated deposits of limited lateral and vertical extent. Most are typically low in MgO and exhibit a wide variation in CaO content (35-55%).

SOUTHWESTERN NEW BRUNSWICK

Significant Silurian limestone occurs on the coast of the Bay of Fundy near Letang, in the southwestern part of the Province. These rocks comprise part of the Mascarene Series, a sequence of felsic to mafic volcanics and tuffs with minor interbedded clastics including limestone and dolomite. Although, at first glance, reserves of high calcium stone appear fairly extensive at Letang, contamination from argillaceous interbeds and intruded dyke rock would probably require a measure of selective quarrying to maintain consistent and acceptable grade levels.

In general, Ordovician-Silurian limestone resources of New Brunswick are characterized by deposits of poor to low quality stone. Although higher quality deposits are known to exist locally, particularly in Silurian rocks of reefal origin, their distribution is somewhat erratic and reserves at specific sites are usually limited to a few million tonnes. The most favourable region to explore for such deposits flanks the northern boundary of the Miramichi Anticlinorium, along a narrow belt of Silurian-Devonian strata extending southwest from Petit Rocher on the Baie des Chaleurs to the Becaguimec River area, near Woodstock.

CARBONIFEROUS LIMESTONE RESOURCES OF NEW BRUNSWICK[24]

Tim C. Webb
Industrial Minerals Geologist

Carboniferous limestones are mainly associated with Mississippian age rocks in New Brunswick. They are broadly separated into two main rock units: the Windsor Group and the Plaster Rock Formation.

Limestones of the Windsor Group are part of a rock sequence reflecting a period of widespread, shallow marine flooding and subsequent dessication. Most deposits occur in Kings County in narrow, northeast-trending belts along the flanks of regional synclinal structures in the Moncton and Westmorland subbasins.

Windsor limestones have been subdivided into three formations: the Gays River, Parleeville, and Macumber formations. These are considered to be laterally equivalent in part. Of the three, it has been determined that Gays River limestone probably has the most favourable development potential (*i.e.*, better grade and larger recoverable reserves). The thick (up to 30 metres), irregular-bedded, algal carbonate build-ups, which dominate the formation, generally contain 52 to 54% CaO.

Although high-calcium algal build-ups are present locally in the Parleeville Formation, they are less extensive than in the Gays River and are characteristically intermixed with a significant proportion of siliciclastics. With few exceptions, the Parleeville Formation lacks sufficient grade continuity and thickness to be considered as an important source of limestone.

The thin, even-bedded limestones of the Macumber Formation are interpreted to be the down-dip (basinward) accumulation of material eroded from both the Parleeville and Gays River formations. Even though these rocks contain a mixture of high-calcium, siliciclastic, and argillaceous material, the limestone grade is surprisingly uniform, averaging 51 to 52% CaO. Despite this grade consistency, steep dips and lack of sufficient quarry thicknesses in most deposits place constraints on recoverable reserves in most areas.

The Mississippian Plaster Rock Formation consists of a lower member of caliche-type, nodular limestone and shale, and an upper member of diagenetic, nodular gypsum and shale. Although the lower member makes up the bulk of the formation's estimated thickness of 150 to 300 metres, caliche-type deposits are generally the product of secondary processes acting upon soils in semi-arid climates and tend to form nodular to thin inconsistent beds of limestone.

Most limestones of the formation offer very limited development potential. They are generally impure, averaging 45% CaO. Even though, locally, some deposits may be of sufficient grade to meet local agricultural needs, recoverable tonnages are perceived to be rather limited.

Les calcaires du Carbonifère sont principalement associés aux roches de l'âge du Mississipien au Nouveau-Brunswick. Ils sont, d'une façon générale, répartis en deux unités rocheuses majeures : le groupe de Windsor et la formation de Plaster Rock.

Les calcaires du groupe de Windsor font partie d'une paragénèse rocheuse témoignant d'une période d'inondation marine générale peu profonde, suivie d'un dessèchement. La plupart des gisements se manifestent dans le comté de Kings en ceintures étroites nord-est le long des flancs des synclinaux régionaux dans les bassins secondaires de Moncton et de Westmorland.

Les calcaires de Windsor ont été subdivisés en trois formations : les formations de la rivière Gays, de Parleeville et de Macumber. Elles sont considérées latéralement équivalentes en partie. Parmi les trois, il a été établi que le calcaire de la rivière Gays offre probablement le potentiel de mise en valeur le plus prometteur (*c.-à-d.*, une meilleure teneur et des réserves récupérables plus étendues). Les épaisses accumulations de carbonates d'algues (jusqu'à 30 mètres), irrégulièrement litées qui dominent la formation, renferment en général, de 52 à 54 % de CaO.

Bien que des accumulations algales riches en calcium soient localement présentes dans la formation de Parleeville, elles sont moins importantes que dans la formation de la rivière Gays, et elles sont typiquement entremêlées avec une proportion importante de silicoclastiques. À quelques exceptions près, la formation de Parleeville ne possède pas une teneur d'une continuité et d'une épaisseur suffisantes pour être considérée comme une importante source de calcaire.

Les minces bancs calcaires uniformes de la formation de Macumber sont interprétés comme l'accumulation d'aval-pendage (vers le bassin) de matériaux érodés des deux formations de Parleeville et de la rivière Gays. Même si ces roches contiennent un mélange de matériaux silicoclastiques, argileux et riches en calcium, la teneur en calcaire est étonnamment uniforme, avec en moyenne de 51 à 52 % de CaO. Malgré cette uniformité de la teneur, les inclinaisons abruptes et l'épaisseur insuffisante dans la plupart des gisements exercent des contraintes sur les réserves

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[24]Limestone is becoming increasingly important, particularly in the field of pollution control. There has been no concerted effort to update information on the Province limestone resources since 1965. The primary objective of this project is to present information on significant deposits of limestone and dolomite occurring in Carboniferous rocks.

exploitables de la plupart des régions.

La formation de Plaster Rock du Mississipien est composée d'un membre inférieur de calcaire et de schiste noduleux, de type caliche, et d'un membre supérieur de gypse et de schiste noduleux, diagénétique. Bien que le membre inférieur représente l'essentiel de l'épaisseur de la formation estimée de 150 à 300 mètres, les gisements de type caliche sont en général le produit de procédés secondaires agissant sur les sols des climats semi-arides, et ils tendent à former des bancs calcaires non uniformes, de noduleux à minces.

La plupart des bancs calcaires de la formation offrent un potentiel de mise en valeur très limité. Ils comportent généralement des impuretés, avec une moyenne de 45 % de CaO. Même si certains gisements auraient une teneur suffisante pour satisfaire les besoins agricoles locaux, les quantités récupérables sont jugées plutôt limitées.

INTRODUCTION

Most of New Brunswick's major resource-based industries are dependent to some degree on a reliable, nearby supply of limestone or dolomite or their products. In the last 10 to 15 years, limestone (lime) that traditionally was used as a soil conditioner and as a source of aggregate has become an essential chemical with a formidable list of uses. Indeed, limestone is one of the most useful and versatile of all the industrial mineral commodities produced in this province.

The importance of Carboniferous limestone to the Province is well documented. In the past, several of these deposits have provided many local farmers with a nearby, inexpensive source of agricultural lime. Extensive deposits at Havelock, straddling the boundary between Kings and Westmorland counties, presently supply one of New Brunswick's largest limestone manufacturing operations. Havelock deposits have provided a source for more than half a million tonnes of limestone annually for various agricultural, construction, and chemical applications.

Limestones are present in virtually every geological system in New Brunswick, but only in Carbonifer Silurian (Ordovician), and Precambrian strata do they attain sufficient thicknesses and grades to be consid economic.

Physical and chemical specifications for limestone are becoming more stringent and applications are expanding, particularly in the field of pollution control. Relatively plentiful throughout much of New Brunswick, the supply of particular grades, such as high-grade calcium limestone, is surprisingly limited. Therefore, effective prospecting for undiscovered deposits and prudent management decisions affecting known deposits are becoming increasingly important. Exploration programs for limestone have been undertaken both by government and private industry resulting in new occurrences being discovered as well as adding to a plethora of information concerning the evaluation of known deposits.

Over the last 25 years, significant developments within the Province's limestone industry include the expansion of Havelock Lime Works Ltd. into the production of quick and hydrated lime, and the establishment of several new quarries.

PURPOSE AND SCOPE

Since the 1965 publication of J.B. Hamilton"s "Limestone in New Brunswick", there has been no concerted effort to update information on the Province's limestone resources. Information is currently scattered in various Mineral Resources files and reports, and in mineral property assessment reports. The primary objective of this project is to present information on significant deposits of limestone and dolomite occurring in Carboniferous rocks throughout New Brunswick. It is intended to be a handy compilation of data rather than a definitive work on Carboniferous limestone. The assessment of our more well known deposits should provide a starting point for individuals or companies considering exploration and possible future development of New Brunswick's limestone resources.

Both published and unpublished information obtained from Mineral Resources Division files over the last two decades contributed to this project. Included are pertinent data on access, and topographic and geologic settings (stratigraphy and structure) and related exploration or development information pertaining to specific

deposits. Although preliminary observations concerning grades, tonnages, and quarry opportunities are presented for most deposits, it is important to realize that such comments are based on broad generalizations and cannot be considered completely reliable without more detailed evaluation.

Field investigations, completed between the spring of 1983 and the fall of 1984, included extensive sampling and surface mapping of several major Mississippian limestone belts and outcrop areas throughout Kings, Albert, Westmorland, Victoria, and Queens counties. Several smaller local deposits scattered along the Bay of Fundy coast in Saint John County were also examined.

Representative samples from most deposits have been catalogued and are stored at the Fredericton and Sussex regional offices of the Mineral Resources Division. Existing sample analyses, *etc.* from past investigations were compiled. Sample information (*i.e.*, location, description, available analysis, *etc.*), and relevant drill-hole data for most areas have also been assembled.

The final report (near completion) contains detailed descriptions that should acquaint the reader with many aspects of each deposit. Some of the more extensive limestone outcrop belts have been mapped at a scale of 1:10 000.

Carboniferous limestones are mainly associated with Mississippian age rocks in southeastern New Brunswick (Figure 28). They extend from the Sussex area northeast to Hillsborough, along the exposed and up-faulted margin of the Moncton and Cumberland subbasins. Other Mississippian deposits outcrop sporadically along the southern flank of the Marysville Subbasin in Queens County, 40 km south of Fredericton. A relatively isolated deposit is situated in the Plaster Rock Basin of Victoria County in northwestern New Brunswick.

Limestones are generally red-grey to olive-grey in colour, with bedding styles varying from massive to laminated to nodular. Although macrofossils are generally rare, some outcrops contain well-preserved algal structures, and a few brachiopods and other indigenous faunal remains.

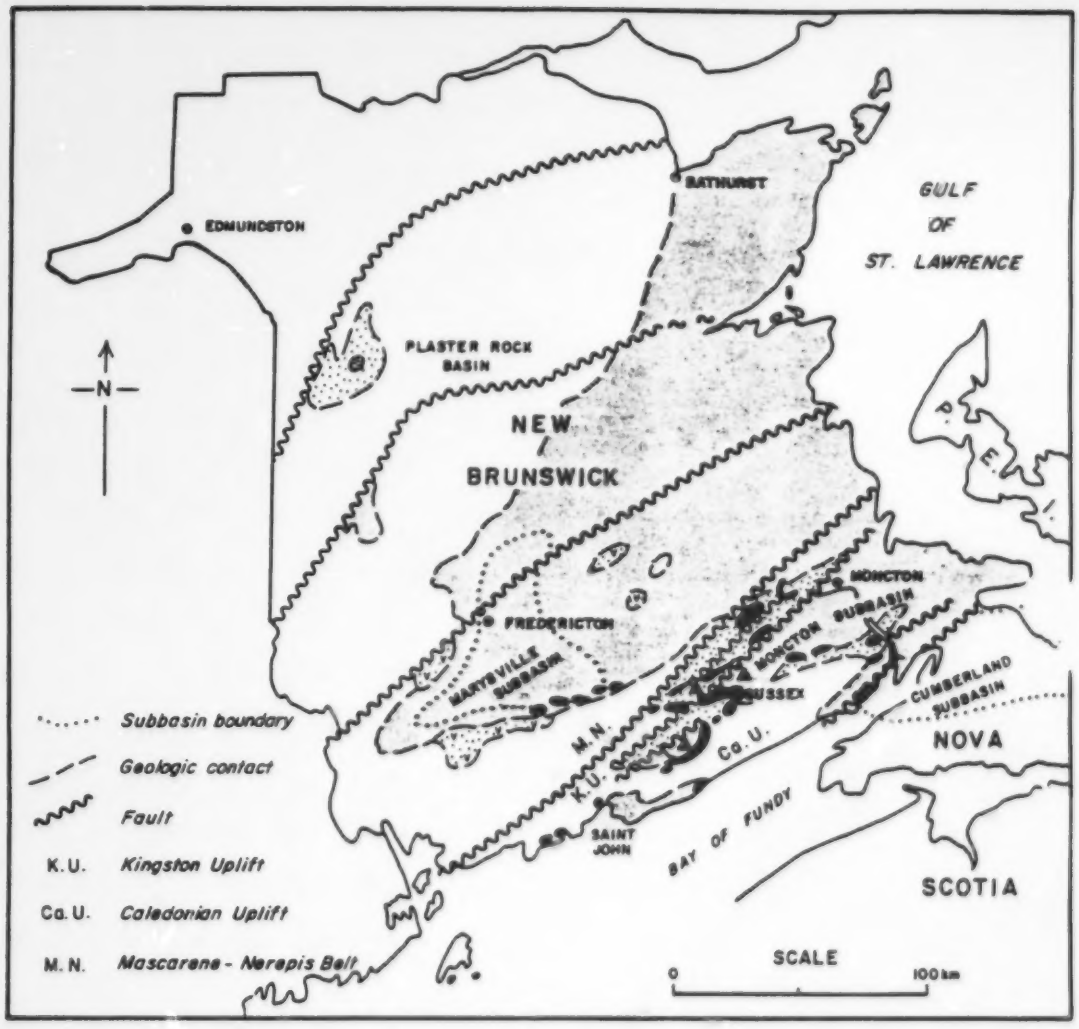
Field exposures and drill core indicate that most Carboniferous limestones are not dolomitized. The extreme western limit of a deposit in the Havelock area is one of the few exceptions.

Locally, Carboniferous limestones have undergone varying degrees of recrystallization, a result of subaerial and burial diagenesis rather than severe metamorphic alteration. Deposits are generally devoid of contaminating veins or dykes. Folds are broad and open with limbs generally dipping less than 45°.

Deposits occur in two limestone-bearing units: the Windsor Group and the Plaster Rock Formation. Lower Viséan, Windsor Group rocks in the Marysville, Moncton, and Cumberland subbasins of southern New Brunswick (Figure 29) are regionally divisible into five recognizable formations (McCutcheon 1981). They are the Gays River, Parleeville, Macumber, Upperton, and Cassidy Lake formations. The first three, found at or near the stratigraphic base of the Group, are of special interest to this project because they contain limestone-bearing units.

Windsor limestones are of marine origin. In the Gays River Formation, massive algal build-ups are dominant, but in the Parleeville Formation, small, isolated algal build-ups are intercalated with calcareous siliciclastics. Both formations are considered, in part, laterally equivalent to very thin- to thin-bedded, euxinic limestones of the Macumber Formation (Figure 30).

Macumber limestones are overlain by Upperton Formation sulphates consisting of stratiform to nodular to mosaic anhydrite at depth, and gypsified anhydrite near the surface. Upperton rocks are also considered, in part, laterally equivalent to the limestones of the Gays River and Parleeville formations. Extensive, homogeneous to heterogeneous salt deposits of the Cassidy Lake Formation overlie, and in places, are laterally equivalent to both the Upperton sulphates and the upper part of the Gays River Formation. Economic deposits of potash in the Cassidy Lake Formation make it an important part of the Windsor Group.



Legend

Mississippian - Pennsylvanian (mainly)

Red and grey conglomerate, sandstone, and siltstone

Middle - Late Mississippian

Windsor Group outcrop area-greenish-grey mudstone, siltstone, shale, limestone, and gypsum

Plaster Rock Formation oucrop area: red shale, limestone, and gypsiferous shale

Late Devonian - Early Mississippian

Red conglomerate, sandstone, shale, and volcanic rocks (v)

Pre-Carboniferous

Basement rocks

FIGURE 28. General geology map showing the regional surface distribution of the Middle Viséan Windsor Group and the location of potash deposits (▲) in New Brunswick.

Map areas

1. Carpenter-Shannon-CFB Gagetown (Plate 88-230)
2. Havelock (Plate 88-240)
3. Nevers Brook
4A. Cape Syncline (West Half) (Plate 88-234)
4B. Cape Syncline (East Half) (Plate 88-235)
5. Smith Creek Anticline (Plate 88-233)
6. Sussex Corner-Urney-Cedar Camp (Plate 88-232)
7. Waterford Syncline (Plate 88-238)
8. Globe Syncline (Plate 88-241)
9. Marshbank Syncline (Plate 88-236)
10. Elgin
11. Intervale-Hillgrove
12. Berryton
13. Hillsborough Albert Mines (Plate 88-231)
14. Shepody
15. Quaco Head
16. South Musquash
17. Halaya Cove (Fort Ledge)

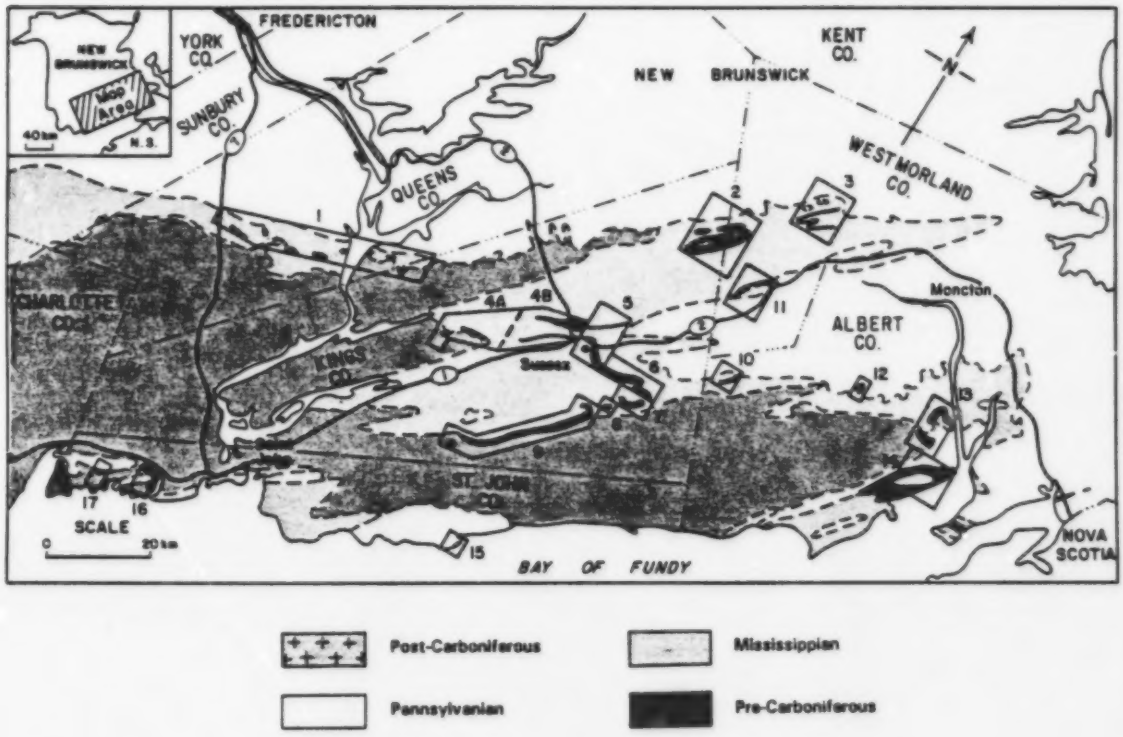


FIGURE 29. Location map showing distribution of Windsor Group outcrop (black) and areas mapped.

Throughout much of southern New Brunswick, the Windsor sequence is disconformably overlain by the Clover Hill Formation, locally comprising nodular and mosaic anhydrite, salt, and/or greenish grey mudstone that eventually grades into a coarsening-upward clastic sequence represented by the Hopewell Group.

Gays River Formation:

The Gays River Formation varies in thickness from 2 to 80 m. It is characterized by mainly olive-grey, shallow-water algal carbonate build-ups consisting of mottled algal boundstone that is often intercalated with variable amounts of thinly bedded wackestone and packstone. The boundstone occurs either as isolated lenses less than 1 m thick and up to several metres in length or as a thick to very thick, massive sequence of stacked algal lenses. Where thinly bedded strata is more dominant than the boundstone, field exposures tend to have a rather "lumpy" appearance (McCutcheon *et al.* 1985); where boundstones are more voluminous, beds are massive and quite indistinct.

Gays River rocks are well exposed around the perimeter of the Moncton Subbasin, a northeast-trending structure bounded on the south and north sides by pre-Carboniferous rocks of the Caledonian and Kingston uplifts, respectively. The internal stratigraphy of the formation varies according to its distance from the pre-Carboniferous terrane. Algal-dominated strata is often found in close proximity to pre-Carboniferous basement

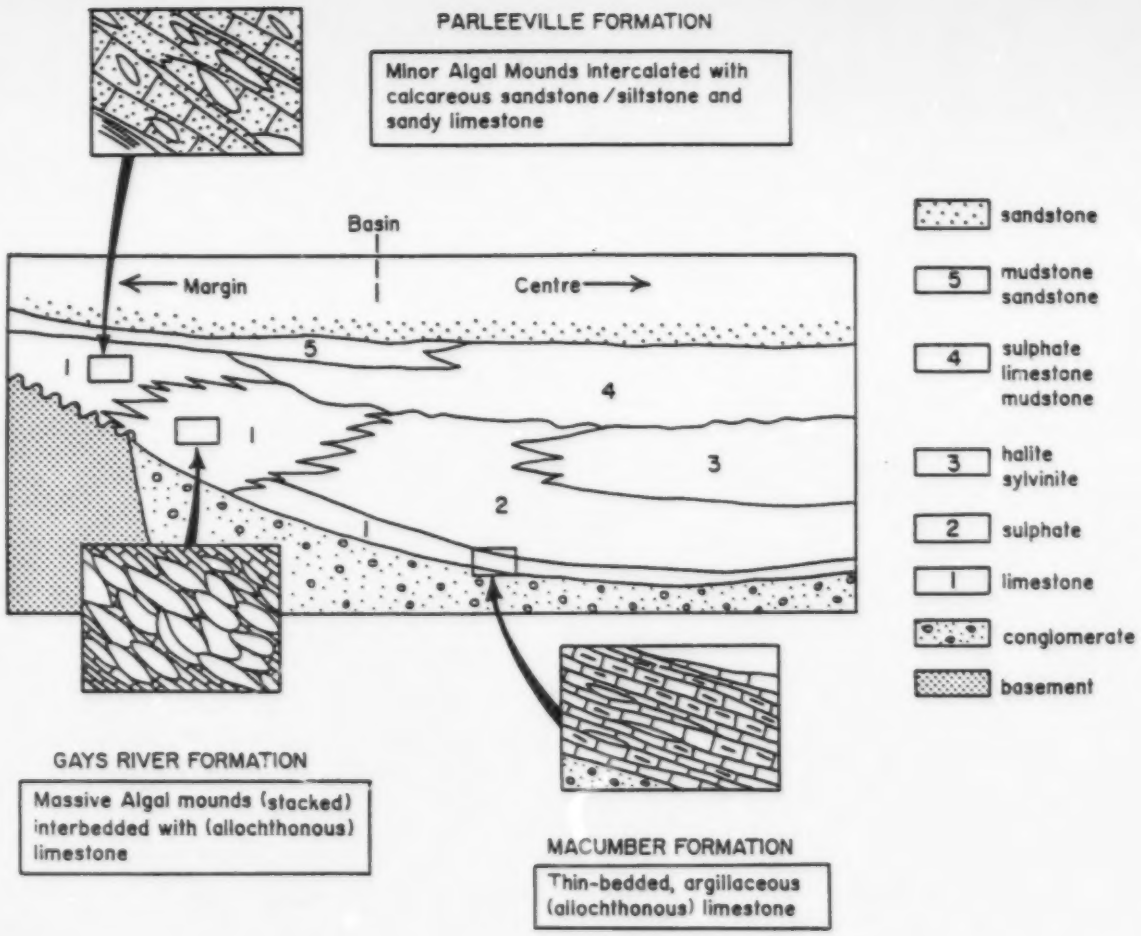


FIGURE 30. Facies relationships within the Windsor Group with special reference to basal limestone-bearing units (modified from McCutcheon 1981). NOTE: no horizontal or vertical scale implied.

rocks. Where the formation is underlain by older Carboniferous sediments, it is generally represented by a basal, interbedded wackestone-packstone with a minor algal bafflestone facies consisting of small stacked algal mound structures. The upper part of the Gays River sequence is locally capped by irregular, thin- to very thin-bedded stromatolitic and oncolitic wackestone-packstone and mudstone ("Samp Hill" beds; McCutcheon 1981).

Parleeville Formation:

The Parleeville Formation (McCutcheon 1981) consists of olive-grey to brownish black, shallow-water, algal carbonate build-ups. These structures are similar to those in the Gays River Formation, however, they are generally much smaller, often found intercalated with varying amounts of thin-bedded greyish red to greenish grey, fine- to medium-grained siliciclastics. Observed thickness of this formation ranges from 1 to 22 m. Scattered outcrops of the Parleeville rocks are found along the northern and southern flanks of the Kingston Uplift (Mascarene-Nerepis belt), a clastic source area during Windsor deposition (McCutcheon 1981). Isolated occurrences have been noted along the Bay of Fundy coast several kilometres east and west of Saint John.

Macumber Formation:

Macumber Formation limestones are characterized by thin-bedded and laminated, olive-grey to dark grey wackestone-packstone reaching thicknesses of up to 18 m. These rocks typically occur on the down-dip or

basinward side of the Gays River Formation and disconformably overlie older Carboniferous strata in both the Moncton and Cumberland subbasins. The allochthonous nature of these rocks is demonstrated by an abundance of algal intraclasts and pelletoids probably derived from up-dip Gays River strata. A coarse intraformational breccia generally marks the transition between these formations.

The evenness of the lamination, a lack of algal build-ups, and *in situ* faunal remains, and the typical argillaceous nature of the limestone indicate that the Macumber was probably deposited in a deeper water environment.

During the course of this investigation, it was determined that Gays River limestone probably has the most favourable development potential (*i.e.*, better grade and larger recoverable reserves) of all the Windsor limestone-bearing formations. These thick, irregular-bedded, algal carbonate build-ups, which generally contain 52 to 54% CaO, are commonly found resting upon or near intrabasinal basement highs (Figure 31). These areas, being somewhat elevated above the sediment-laden bottom waters of the near-shore and the hypersaline brines collecting in the deeper parts of the basin, provided a favourable niche for a flourishing algal community, which played an integral part in the organic concentration of $CaCO_3$.

These elevated areas, virtually free of terrigenous contamination, played an important role in the diagenetic development of the limestone deposits. During the initial stages of deposition, rapid decay within the algal mounds resulted in the development of a significant primary porosity. Upon subaerial exposure, the porous limestone probably acted as an effective plumbing system, allowing undersaturated $CaCO_3$ solutions to dissolve the limestone at some locations and precipitate $CaCO_3$ at others. This recrystallization process is evident in the Gays River limestone and has produced a number of favourable physical properties, such as large crystal sizes and a well-developed secondary porosity that significantly enhances the calcining properties of crushed limestone in the production of lime.

A characteristic of the Gays River limestone is its rapid change in apparent thickness laterally, sometimes within a few tens of metres. This is believed to be due to unexpected irregularities in the basement topography. One must therefore take this into consideration when evaluating deposits.

Although high-calcium algal build-ups are present locally in the Parleeville Formation, they are less extensive than in the Gays River limestone and are characteristically intermixed with a significant proportion of siliciclastics. These rocks, considered to be a near-shore equivalent of Gays River strata, are typified by both rapid vertical and lateral facies variations (Figure 31). With few exceptions, the Parleeville Formation lacks sufficient grade continuity and thickness to be considered as an important source of limestone.

The thin, even-bedded limestones of the Macumber Formation are interpreted to be the down-dip (basinward) accumulation of material eroded from remnants of both the Parleeville and Gays River formations (Figure 31). Even though these rocks contain a mixture of high-calcium, siliciclastic, and argillaceous material, the limestone grade is surprisingly uniform, averaging 51 to 52% CaO, but is generally lower than the grade of Gays River limestone. Despite this grade consistency, steep dips and lack of sufficient thickness of most deposits limit recoverable reserves in most cases.

Of all the Windsor Group deposits investigated, the limestones of the Gays River Formation, particularly those in the Havelock area, have the highest potential for development. In fact, Havelock deposits are the only Carboniferous limestones currently being worked on a commercial scale in the Province.

The Mississippian Plaster Rock Formation, 150 to 300 m thick (St. Peter 1979), consists of a lower member of caliche-type, nodular limestone and shale, and an upper member of diagenetic, nodular gypsum and shale. The lower member makes up the bulk of the formation's estimated thickness.

Caliche-type limestone deposits are generally the product of secondary processes acting upon soils in semi-arid climates. Extensive evaporation in such an environment causes an upward movement of calcium bicarbonate ($Ca(HCO_3)_2$) and "soil water" (vadose water) by capillary action (Figure 32). As this water moves toward the surface, it is gradually warmed and the partial pressure of CO_2 (carbon dioxide) decreases significantly. Under these conditions, the mobile calcium bicarbonate solution becomes unstable and dissociates

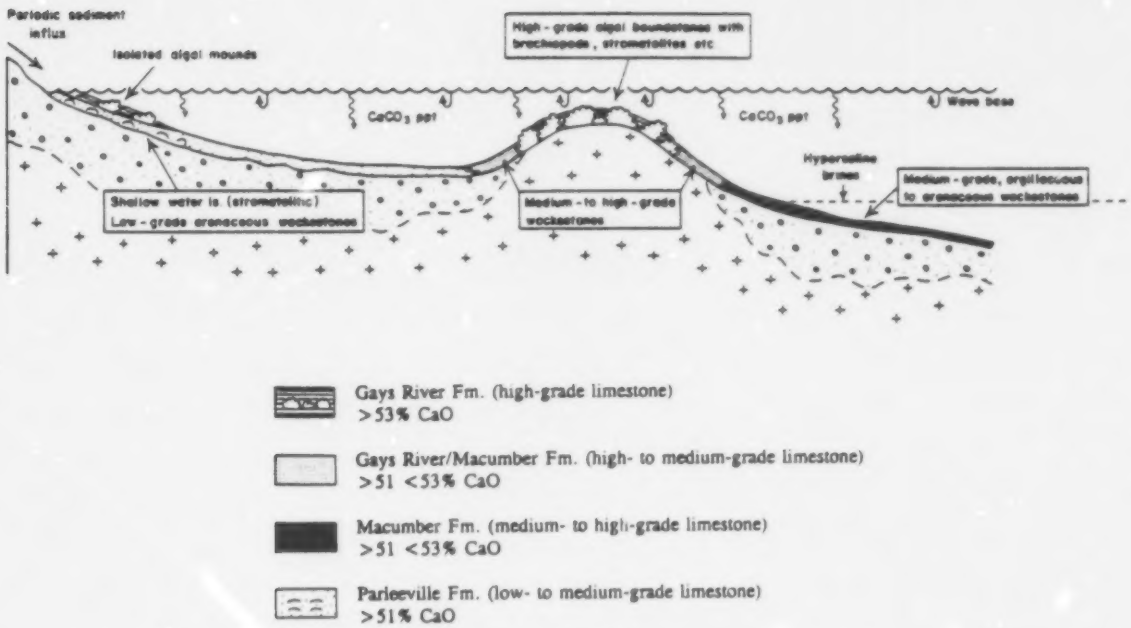


FIGURE 31. Schematic diagram of Windsor Group limestone facies and grade distribution during the transgressive carbonate depositional stage.

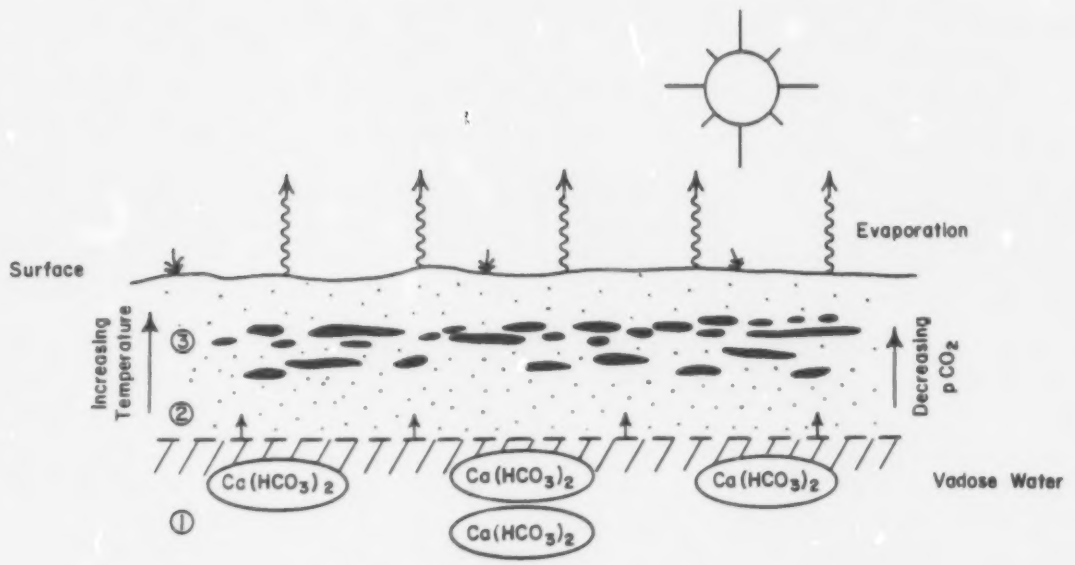


FIGURE 32. Explanation for the formation of caliche-type limestone deposits of the Plaster Rock Formation, Victoria County, New Brunswick.

into water (H_2O), carbon dioxide (CO_2), and calcium carbonate ($CaCO_3$). The excess water is evaporated, the CO_2 evolves as a gas, and the $CaCO_3$ is left behind forming nodules and irregular beds of limestone.

Most limestones of the Plaster Rock Formation offer very limited development potential. They are generally impure, rarely exceed 50% CaO, and average 45% CaO or less. Even though some deposits may be of sufficient grade to meet local agricultural needs, recoverable tonnages are believed to be extremely limited. In addition, large-scale quarry development in most areas would be an expensive, if not impossible, undertaking due to variable overburden thicknesses and the proximity of most potential sites to major waterways.

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A NEW "DIMENSION" TO MINERAL EXPLORATION AND DEVELOPMENT IN NEW BRUNSWICK[25]

Tim C. Webb
Industrial Minerals Geologist

Over the last decade, there has been a remarkable rejuvenation in the popularity of stone in many architectural, streetscaping, and general construction applications. This noticeable change in attitude is attributed to many factors. Environmental concerns, technological advances in quarrying and processing, shifts in artistic expression and nostalgia have played key roles.

Dimension stone is a very modest part of the Canadian rock and mineral industry and yet it probably ranks among the Nation's fastest growing industries in output and trade. Recent statistics suggest that Canadian production of rough granite used in the construction sector has increased significantly over the last decade – from a meagre 27 000 tonnes valued at slightly less than $1.2 million in 1978 to 100 000 tonnes with a reported value of $15.8 million in 1988.

When considering stone for a particular application, the importance of quality control, affected largely by geological processes is critical to the ultimate success or failure of what may at first appear to be a promising stone prospect. The geologic evolution of a rock mass is extremely important in determining properties such as maximum quarry block size, colour and texture, imperfections, structural integrity and mineralogy. Equally important to a successful dimension stone enterprise are operational factors involving several logistic aspects of quarry development and market intelligence.

New Brunswick's dimension stone industry thrived from the late 1800s to early 1900s, supplying stone for buildings, monuments and other structures throughout eastern Canada and the United States. Promotion and revival of materials from some of these old quarries could result in renewed interest, particularly for restoration and renovation applications across eastern North America. As well, other prospects possessing stone with vibrant colours and aesthetic appeal have been identified at several locations in the Province and may be considered as possible targets for further evaluation.

Success in rekindling interest and expanding the profile of the Province's dimension stone resources depends on a number of factors. The recognition of stone with unique colour and textural qualities, the gathering of relevant technical data on the resource, identifying potential market niches and product limitations, and creating an awareness of the versatility and viability of the resource among potential user groups are all of considerable importance.

La dernière décennie a toutefois été témoin d'un spectaculaire regain de popularité de la pierre dans un grand nombre d'utilisations en architecture, en aménagement urbain et dans la construction en général. Ce changement d'attitude notable est attribuable à un grand nombre de facteurs. Les préoccupations environnementales, les progrès technologiques réalisés dans l'exploitation des carrières et la transformation, les changements d'expression artistique et la nostalgie ont joué des rôles clés.

La pierre de taille occupe une modeste part de l'industrie canadienne des roches et des minéraux; pourtant, elle se classe probablement parmi les industries du pays dont la croissance est la plus rapide en fait de production et de commerce. Des statistiques récentes révèlent que la production canadienne de granit brut utilisé dans le secteur de la construction a augmenté de façon substantielle au cours de la dernière décennie. Elle est, de fait, passée de seulement 27 000 tonnes, évaluées à près de 1 200 000 $, en 1978, à 100 000 tonnes, d'une valeur approximative de 15 800 000 $, en 1988.

Lorsqu'on songe à la pierre en vue d'une utilisation donnée, l'importance du contrôle de la qualité, largement tributaire des processus géologiques, est déterminant pour le succès ou l'échec ultimes de ce qui, à première vue, peut sembler une perspective prometteuse. L'évolution géologique d'une masse rocheuse revêt une importance extrême dans la détermination des propriétés, notamment les dimensions maximales des blocs de carrière, la couleur et la texture, les imperfections, l'intégrité structurale et la minéralogie. Il ne faut pas négliger les facteurs d'exploitation, qui comprennent plusieurs aspects logistiques de mise en valeur d'une carrière et d'information commerciale pour la réussite d'une entreprise de pierre de taille.

L'industrie de la pierre de taille au Nouveau-Brunswick a été florissante de la fin du XIX[e] siècle au début du XX[e] siècle, fournissant bâtiments, monuments et autres structures dans tout l'est du Canada et des États-Unis. La promotion et la renaissance des matériaux de certaines de ces anciennes carrières pourraient engendrer un regain d'intérêt, particulièrement au niveau de la restauration et de la rénovation dans l'est de l'Amérique du Nord. De

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[25]Over the last decade, there has been a noted rejuvenation in the popularity of natural stone as a building material. The objective of this project is to show that dimension stone and related architectural stone could have economic potential in the Province.

même, d'autres pierres dignes d'intérêt, aux couleurs vivantes et présentant un attrait esthétique, ont été répérées dans plusieurs endroits de la province, et on pourrait les considérer comme des objectifs possibles en vue d'une évaluation plus détaillée.

Le succès à raviver l'intérêt et à accroître le profil des ressources de la pierre de taille au Nouveau-Brunswick dépend d'un certain nombre de facteurs. La reconnaissance des pierres aux qualités uniques du point de vue couleur et texture, la collecte des données techniques pertinentes à la ressource, la détermination des créneaux de marché potentiels et l'instauration d'une sensibilisation à la polyvalence et à la viabilité de la ressource parmi les groupes d'utilisateurs éventuels, ont tous une importance énorme.

INTRODUCTION

To most New Brunswickers, mining in the Province is synonymous with the extensive base-metal and potash operations in the Bathurst-Newcastle and Sussex areas respectively. Undeniably, zinc and copper concentrates and potash form the basis of the Province's mineral industry contributing over $760 million annually to the total value of mineral and rock products produced. There is however another form of "mining" which has taken place in New Brunswick - "mining" that has over most of the last century been generally ignored or seriously considered by the mineral industry. The mining, or more appropriately the quarrying, of stone for use either in its natural or dimensioned state for construction purposes has a longevity and established presence in the Province that far outdates the earliest metal-mining ventures.

At present, only a few quarries are periodically worked specifically for dimension stone. These operate generally on a demand basis, providing stone for specific architectural projects and for numerous utility purposes. Despite the apparent deficiency of active quarrying, there are several local firms capable of processing and fabricating a variety of stone products. Unfortunately, for one reason or another imported blocks of stone are generally favoured over indigenous sources.

Under the right conditions, a suitable "deposit" of natural stone can be considered a potential "added value" mineral resource. As an example, a quarry producing rough granite blocks in central Canada can expect to sell them for about $120 per tonne (f.o.b. quarry) (Beard and Kennedy 1987). However, the value of the stone when enhanced by several finishing techniques is in excess of 10 times ($1200 per tonne) its initial value. Despite what would appear to be a rather lucrative enterprise, interest in New Brunswick's natural stone resources has not attracted much more than casual attention since the mid 1800s to the early 1900s. The dimension stone industry has therefore lagged far behind the prosperity of the metallic and other mineral-based sectors of the provincial economy. Recent architectural trends and preferences combined with much improved stone processing techniques and construction practices and an increased public awareness and perception of natural stone as a realistic, alternative building material would suggest some opportunities may in fact exist for a much expanded industry in the future. The possibility of this has resulted in renewed efforts to promote and evaluate stone resources throughout the Province.

TECHNICAL EVALUATION AND OPERATIONAL CRITERIA FOR DIMENSION STONE DEPOSITS

It is probably fair to say that almost every kind of rock can to some extent be utilized as dimension stone. However, when considering a particular type of stone for a specific application, the importance of quality control, affected largely by geological processes and other factors related to marketing, are critical to the ultimate success or failure of what may at first appear to be a promising stone prospect. Some of the geological and operational criteria that determine the destiny of a deposit are expanded upon in the following section.

Geologic Criteria:

The suitability of a rock as a source of dimension stone depends on its market appeal - a function of its aesthetic and physical qualities and its availability. Aesthetic appeal is a matter of personal taste and preference and is therefore difficult for the average field geologist to come to grips with. However, one realises that the basis of a rock's architectural value is its colour, texture, structural integrity, and capability to be quarried. These qualities are a function of primary and secondary geological processes; they instill a certain uniqueness to natural stone that competing construction and decorative materials fail to duplicate effectively. A clear understanding of the geology is important in the assessment of a dimension stone prospect.

Block size:

Depending on the intended end use, the availability of large uniform quarry blocks is one of the most important requirements of a potential dimension stone deposit. In most cases, the efficiency of the quarry technique and subsequent fabrication into finished products is directly related to block size and minimizing the waste factor (Verschuren *et al.* 1989) (*i.e.*, the smaller the block size the greater the processing costs). Block size is a direct consequence of the geologic evolution of a deposit and is determined by the geometry of fracture and jointing patterns. Ideally the potential for large blocks is enhanced where the incidence of jointing is minimized or where joints occur as widely spaced, vertical to very steep dipping sets.

Colour and Texture:

Apart from structural properties, the market appeal and value of stone used for decorative purposes is primarily a function of its overall appearance, determined for the most part by its colour and texture. Of the two, colour is perhaps the single most important factor affecting the marketability of a stone. It is a unique blend of the stone's mineralogical and textural properties. Although textural consistency is desirable, variations can be tolerated and in some applications may even enhance the market appeal of a stone. In general, fine-grained, melanocratic stones command premium prices and are valued higher than coarser-grained leucocratic varieties. This is in part due to the fact that flawless, fine-grained stones are more difficult to obtain.

Features such as veins, dykes, clusters of coarse crystals (schlieren structures), and inclusions (*i.e.*, xenoliths - assimilated wall or country rock often referred to in the industry as "knots") are causes of irregularities in colour and texture and can therefore detract from the quality of a stone. The frequency of such imperfections obviously has a direct bearing on the maximum size of flawless stone and on waste-to-product ratios. Although imperfections can occur throughout a plutonic body, they can be expected to be more persistent within its outer margins.

At one time, stone with an abundance of natural blemishes was considered totally undesirable, however it now appears to be receiving limited market acceptance for certain applications. In some instances, imperfections add a certain uniqueness to a stone, which can be a determining factor in its selection for a particular effect or project. Similarly, flawed stone can often be considered for utility purposes such as curbing where aesthetic appeal is secondary to cost. This allows stone that would otherwise be considered quarry waste to be sold, thereby reducing quarrying costs of premium material. Whereas colour uniformity is desirable, multi-coloured stones such as "patterned" or "colour-banded" granites (gneisses, etc.) continue to gain market acceptance in certain applications.

Structural Integrity (physical properties):

The suitability of a stone for a specific application must conform to a number of physical standards. The most common guidelines followed are those established by the American Society for Testing Materials (ASTM). This organization has devised a series of standard quantitative tests covering a wide range of properties. Among the common considered are: compressive strength, modulus of rupture (transverse strength), abrasion resistance, absorption, and density. Minimum and maximum specifications must be realized depending on the type of stone and intended use.

Mineralogy, textural variation, natural cementing agents and hidden fractures all combine to determine the structural strength of a stone. Generally, fine-grained rocks are "tougher" than coarse-grained varieties (Winkler 1975), a result of structural weaknesses developed along natural planes of cleavage.

Mineralogy:

Stone considered for exterior purposes should be relatively free of any minerals that have the potential to undergo severe alteration during natural weathering processes. Stones containing excessive amounts of the sulphide minerals pyrite and marcasite automatically become questionable candidates for exterior uses (Currier 1960). Micas are also susceptible to mechanical effects weathering, which may manifest itself in bleaching. Ferriferous varieties of amphibole (chiefly hornblende), a common constituent in granite weather quite rapidly. Nonferrous amphibole namely tremolite and diopside deteriorate rapidly and should be avoided (Currier 1960). Feldspar, a major component of granite can be slowly altered in nature by carbon dioxide in soil and ground water. Other alteration products resulting from sericitization, chloritization, and epidotization are also reason for concern but in some instances can enhance a stone's aesthetic value by virtue of their effect on colour.

Not only does mineralogy play a significant role in the aesthetic appeal and long term durability of a stone; it also has a important impact on processing costs. For example, excessive biotite, apart from its higher susceptibility to weathering, tends to "pluck" during the polishing process resulting in a finished product with a somewhat pitted surface. Stone with a high percentage of free quartz (>30%) is extremely hard causing increased wear and tear on fabrication equipment (Verschuren *et al.* 1989). This ultimately results in higher maintenance and production costs.

OPERATIONAL CRITERIA

Favourable geological conditions without question form an integral part of the development potential of any dimension stone deposit. Nonetheless there are several other factors related to operational matters that almost equally important. These involve:

* **Quarry development concerns**
- topographic setting
- land tenure
- waste management
* **Market intelligence**
- market size and growth prospects
- transportation and inventory management
- meeting various specifications
- competition
- price
- international trading patterns

Quarry Development:

The **topography** of a prospective quarry site has a direct **impact** on the **extraction method(s)** employed which ultimately effect quarrying costs.

Acquiring **tenure to** dimensional stone **reserves** must be considered early on during the appraisal phase of any prospect. In Canada, the acquisition of quarrying rights differs from Province to Province. For example, New Brunswick's Mining Act classifies dimensional stone as "ordinary stone used for building or construction " and therefore it is not considered a" mineral" (Mining Act 1985). Of course, dimensional stone is anything but ordinary, but as defined it falls outside the jurisdiction of the Mining Act which conditionally guarantees access to most mineral resources within the Province. Ownership to stone resources is therefore vested with the landowner. On private or freehold property, development rights must be secured through direct land purchase or a negotiated lease agreement or other arrangement with the landowner. For lands owned and administered by the Province (Crown lands), access to stone reserves can usually be achieved through guidelines established in the Quarriable Substances Act.

Depending on the type of stone and its geologic properties, dimension stone quarries produce a substantial amount of **waste rock** referred to as "grout". If a market for grout material could be realized, the cost of quarry development would be reduced.

Market Intelligence:

Generally, markets for dimension stone in North American have shown rather remarkable growth over the last several years and except for a few fluctuations this trend is expected to continue over the long term (Prud'homme 1991). Although there appear to be grounds for optimism considering the overall market picture, regional demand is often more difficult to quantify (Harben and Purdy 1991).

The attitude and experience of local architects and building designers toward the application of stone in their designs determines the type of stone that will be used and the location best suited to supply it. Other factors that weigh heavily on a decision to select stone over alternate building materials include: fashion, practicality, transportation, availability, price, and international trading patterns.

Long-term trends in **fashion** are probably among the most difficult to predict. Colour preferences tend to be as fickle as Maritime weather.

Despite all the apparent importance placed on fashion, **practicality** usually prevails at some point of the selection process and probably is a significant factor, accounting for regional differences in taste. Examples of practicality would be the obvious suitability of a particular type of stone used almost exclusively in warm climates as opposed to that considered both tasteful and able to stand the wide temperature variations of more temperate environments (*i.e.*, Florida versus New England).

Compared to metallic mineral resources, dimension stone has a lower unit value per unit weight. A significant portion of the delivered cost of stone is **transportation**. In some cases, this alone can add as much as 70% to the price of a rough quarry block. Minimizing this cost is important in the determination of pricing structure, and market competitiveness of a prospective quarry.

The market **availability** of a stone will also often influence its choice in a project. In North America this particular requirement has been met over the last few years to some extent by a number of large stock importers or "stone yards" which distribute both processed (*i.e.*, slabs, tiles etc.) and rough stone products. These firms maintain a substantial stone inventory as well as display samples in showrooms much the same way flooring or wallpaper products are marketed. A prospective dimension stone producer would be well advised to investigate the merits of establishing business ties with such distribution centres. However, this approach should only be undertaken following the adoption of a detailed development plan and a list of product lines that have been confidently identified.

It is a well established fact that competition in the dimension stone business is fairly intense. One can not overstate the importance of reputation and the impact of the so called "word of mouth" recommendation on a prospective buyer. The apparent return to the use of stone has resulted in plethora of new firms supplying stone to a virtual global market. Consequently, newcomers must be diligent in developing a rapport with prospective clients in order to successfully compete with established companies.

Considering other factors that affect competition, **price** ultimately enters the picture. The ability to provide quality products at competitive prices has a direct impact on projected profit margins. A new producer must study the cost structure of competing products to determine a minimum price that will ensure a reasonable return on investment. The impact of the European Economic Communities integration in 1992 and the development and market re-entry of Asian, Latin American, and Third World countries could have a profound effect on **international trading patterns** and global distribution of dimension stone. Stone from these sources has the potential to alter consumer prices; however, the need to maximize hard currency returns to improve living standards may override the competitive tendency to flood the market place with "cheap" stone.

In a North American context it remains to be seen what affect the Canada-United States Free Trade Agreement (Zielinski and Maynard 1989) and the proposed Continental Open Trade Agreement (Canada-United States-Mexico) will have on the cross-border movement of finished stone products. The end result may well be the freer flow of stone making it ultimately more affordable.

POTENTIAL OPPORTUNITIES FOR DIMENSION STONE IN NEW BRUNSWICK

Given the trend toward natural stone as a building material of choice, and New Brunswick's diverse geology and past history of successful production, it would seem that dimension stone and related architectural stone products have the potential to play a more prominent role in the future direction of this resource development in the Province. The impact of stone will depend on an assessment of potential stone products the Province's resources are capable of sustaining. For the most part, surface exposures of the Province's granite resources reveal complex joint patterns, and moderate to intense fracturing. Whether or not this condition persists at depth is unknown. The distribution of imperfections and textural variations in some deposits, (*i.e.*, xenoliths, etc.) can often vary over short distances. Such characteristics place certain restrictions on the size and quality of stone products that can be expected and are synonymous with high waste-to-product ratios. Success in developing most New Brunswick granites as a viable source of large panels or veneer would appear to be rather remote. One would have to seriously consider the marketing of quarry waste to make such an operation feasible.

Although a number of specialty products are unique to a region by way of colour and/or texture,

opportunities may exist for smaller local entrepreneurs to market several product lines that large out-of-Province producers may be inhibited from supplying due to high transportation costs and other factors. Potential market development may at first be of a local nature pertaining to residential and other construction products such as finished tiles, land and streetscaping stone (*i.e.,* curbing), pavers, crushed decorative aggregate, quality flagstone, and ashlar (*i.e.,* planters, walkways, retaining walls, *etc.*) and "crazy stone". These product lines appear to be grossly underdeveloped in the Atlantic Provinces.

There may also be opportunities particularly in the restoration and renovation of structures originally constructed of New Brunswick stone during the industry's most successful period of operation over 100 years ago. The importance of such a market should not be under-rated.

The market for crushed ornamental stone and boulders also offer interesting possibilities. Such material is in demand for general landscape purposes, exposed aggregate concretes, structural stone for slope stabilization and erosion protection, and a host of utility applications. A recent visit to several retail firms in the Province indicate very little colour selection of bagged decorative aggregate products (mainly red brick and white marble chips), with the majority of material imported from outside the region. Significant waste piles exist at abandoned quarry sites throughout New Brunswick offering stone in a wide range of colours and textures. If such material could be utilized, it would offer not only a marketable product but would also contribute to the rehabilitation of an abandoned site to one of a more environmentally acceptable condition. There is also potential for unique stone products from locations not previously developed.

CONCLUSION

It would seem that an appreciation and reacceptance of stone as a viable, cost-competitive building material is greater now than it has been for some decades. The trend may be considered partly a nostalgic link to our past, but in essence the excellent condition of many stone structures erected well over 100 years ago provide visible reminder of the long-term cost effectiveness and reliability of natural stone as a building material compared to modern alternatives. It is no coincidence that six out of seven "Wonders of the World" are made of stone.

Aesthetic appeal and a shift in architectural taste throughout North America is but another attraction of stone. Stone emits a certain ambience of true craftsmanship and art as opposed to structures of man-made alternatives such as concrete, steel, and plastic.

At a time when environmental concerns and energy savings are paramount, the increased use of natural stone makes perfect sense. Man-made construction materials and practices instrumental in the destruction of the stone industry in the early 1900s may in fact be among some of the very factors responsible for its future success. Manufactured construction materials such as cement, metals, plastic, and glass have become costly to produce, partly a result of high energy cost, high labour costs, inflation, and strict environmental standards. Increases in the price of stone, however, have been largely offset by improvements in both quarry extraction and processing. In addition, new fastening techniques and a trend toward prefabrication have helped reduce installation costs. All these developments have brought the price of stone in line with alternatives in numerous applications. For example, the production of cement requires vast amounts of energy. The fuel component in particular can account for as much as 75% of production costs. Cement is not the only a large energy consumer – brick-making also demands a sizable energy input. In an era where the burning of fossil fuels is viewed a major contributor to acid rain and the "greenhouse effect" and as energy conservation is fast becoming a matter of necessity, the use of natural stone as a primary construction material seems to be a logical and cost-competitive alternative. Most stones are relatively inert, environmentally friendly substances. Properly maintained, they are generally not susceptible to adverse chemical reactions like alkali reactivity, which can cause premature deterioration in modern concrete structures, some less than 20 years old. Stone generally requires less energy to quarry and process than an equivalent volume of cement.

It is also interesting to note that stone can be replaced in or added to a structure, often closely matching existing material, an important consideration for renovation and restoration work. The advantages of stone over alternative materials is bolstered by its proven record as a tough utility material,(*i.e.,* granite curbing).

Success in rekindling interest and expanding the profile of New Brunswick's dimension stone resources depends on several elements: the recognition of stone with unique colour and textural qualities, the gathering of relevant technical data on the resource, the identification of potential market niches and product limitations, and encouraging the awareness of the versatility and viability of the resource among potential user groups. These are all of considerable importance.

Basic geological investigations, (*i.e.*, regional mapping programs) carried out by the Geological Survey of Canada and New Brunswick's own Geological Surveys Branch (Department of Natural Resources and Energy), are extremely important in the recognition and the preliminary evaluation of potential sources of stone. This approach sets the foundation of an effective database for future reference. Although at first glance it may appear that our domestic resources are extensive, stone meeting all the most favourable physical, aesthetic, and logistical criteria from a development perspective, is often the exception rather than the rule. Once an area has been identified as a potential source of durable and attractive material, every effort should be made to preserve it by proper resource management decisions.

Whereas the prevailing period of sluggish economic growth (1991) has brought about a corresponding abatement in demand for construction products – dimensional stone products no exception – sales are predicted to increase within the next 5 years or so. Now is the time to be examining potential development initiatives pertaining to New Brunswick's relatively untapped resources of natural stone. This approach should place the Province in a good position to take full advantage of improved markets in the years to come.

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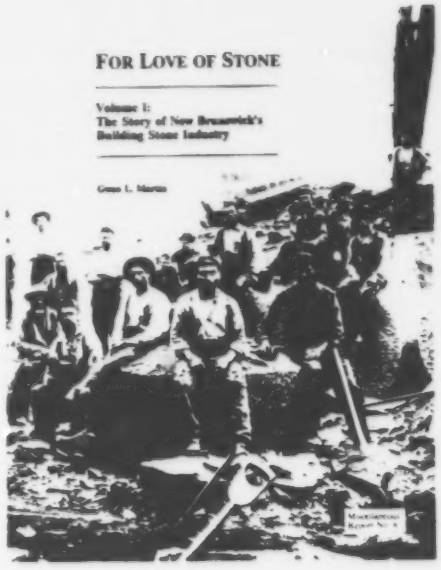
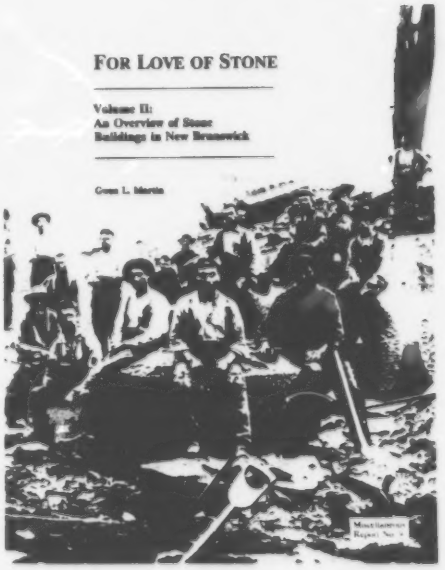
"FOR LOVE OF STONE"

Over the last decade, there has been a general revival of interest throughout North America pertaining to the use of natural stone as a viable construction material. Attention has not only been directed at new construction but has also been targeted at the restoration and renovation of vintage stone buildings and related structures. These events prompted the Department of Natural Resources and Energy to sponsor a research project chronicling the history of the New Brunswick building stone industry.



"For Love Of Stone" represents two years of very dedicated research by Gwen L. Martin. It examines the rise and fall of the Province's building stone industry as well as its possible rejuvenation using both historical and architectural data to chart its evolution.

Stoneworking in New Brunswick originated thousands of years ago with its Native people, who made stone tools, weapons and ornaments. In the 1600's, the earliest Acadians erected the Province's first stone buildings, most of which were destroyed by British troops in the middle to late 1700's. When New Brunswick society finally became stable enough to encourage permanent settlement, stone churches, gaols, public buildings, and houses sprung up in populated regions across the Province. Several of these structures are still in daily use.



The building stone industry began in earnest during the mid-1800's after signature of a Reciprocity treaty between Canada and the United States. This nineteenth century free-trade agreement allowed Canadian stone to enter the U.S. without duty, and lured Americans to invest in the Provincial stone business. Between 1855 and 1900, New Brunswick stone was shipped throughout eastern North America from Charlotte, Westmorland, Albert, and Northumberland counties.

Sandstone and granite quarries constituted by far the greatest number of New Brunswick stoneworks. Sandstone production peaked between the 1840's and 1890's; it came mostly from Westmorland and Albert counties, near Newcastle and along the Bay of Chaleur. The most important granite quarries were near St. George, Hampstead, and Bathurst. Although the granite industry began in 1879, its greatest development took place between the 1870's and 1920's, and involved more monument than building stone production.

After about 1920, the development of artificial substitutes, high transportation costs, inflated American tariffs, and lessened stone demand all combined to cripple the New Brunswick building stone industry. Many structures made of New Brunswick stone still stand across eastern North America, more than a hundred of them in our own province. Yet the stone industry itself has dwindled mightily, its vibrant and romantic past as littleknown as its respectable if modest present. A few stone quarrying firms still remain active in the Province

while several other firms produce local and foreign stone for restoration, monumental and streetscape purposes.

"For Love of Stone" is published in two volumes. Volume I gives a detailed account of the stone industry over time - its inception and prime, its decay and collapse, its potential future - and describes some of the people who helped make New Brunswick stone famous. Volume II is an overview or catalogue of selected stone buildings and structures in the Province. It supplements Volume I, and serves as an independent reference text for designers, heritage planners and others who need information on provincial stone architecture.

«FOR LOVE OF STONE»
(Pour l'amour de la pierre)

La dernière décennie a connu un regain général d'intérêt en Amérique du Nord pour la pierre naturelle comme matériau de construction viable. L'attention ne s'est pas uniquement portée sur les nouvelles constructions, mais également sur la restauration et la rénovation de bâtiments anciens en pierre et des structures connexes. Ces activités ont poussé le ministère des Ressources naturelles et de l'Énergie à parrainer un projet de recherche visant à reconstituer l'histoire de l'industrie de la pierre de construction au Nouveau-Brunswick.

«*For Love of Stone*» représente deux années de recherches poussées réalisées par Gwen L. Martin. Le document analyse l'essor et la chute de l'industrie de la pierre de construction de la province, ainsi que son rajeunissement éventuel en utilisant les données historiques et architecturales pour tracer son évolution.

Les origines du travail de la pierre au Nouveau-Brunwick remontent à des milliers d'années, à l'époque où les aborigènes fabriquaient des outils, des armes et des ornements en pierre. Au XVII[e] siècle, les premiers Acadiens construisirent les premiers bâtiments en pierre de la province. La plupart ont été détruits par les troupes britanniques du milieu à la fin du XVIII[e] siècle. Lorsque la société néo-brunswickoise est finalement devenue assez stable pour favoriser un peuplement permanent, des églises, des prisons, des édifices publics et des maisons de pierre surgirent un peu partout dans les régions habitées de la province. Plusieurs de ces structures sont encore utilisées de nos jours.

L'industrie de la pierre de construction a connu un essor considérable vers le milieu du XIX[e] siècle, après la signature d'un traité de réciprocité entre le Canada et les États-Unis. Cette entente de libre-échange du XIX[e] siècle a permis à la pierre canadienne de passer aux États-Unis sans droits de douanes, et elle a amené les Américains à investir dans l'industrie de la pierre de la province. De 1855 à 1900, la pierre du Nouveau-Brunswick, en provenance des comtés de Charlotte, de Westmorland, d'Albert et de Northumberland, était expédiée partout dans l'est de l'Amérique du Nord.

Les carrières de grès et de granit ont constitué, de loin, les sources du plus grand nombre d'ouvrages de maçonnerie au Nouveau-Brunswick. La production de grès a atteint son maximum entre les années 1840 et 1890; il provenait surtout des comtés de Westmorland et d'Albert, de la région près de Newcastle et de la bordure de la Baie des Chaleurs. Les carrières de granit les plus importantes se trouvaient près de St. George, d'Hampstead et de Bathurst. Bien que l'industrie du granit ait pris naissance en 1879, son essor a été le plus spectaculaire entre les années 1870 et 1920, et elle a touché davantage la production de monuments que de pierre de construction.

Après 1920, la création de susbtituts artificiels, les coûts de transport élevés, les tarifs américains accrus et la baisse de la demande de pierre se sont combinés pour paralyser l'industrie de la pierre de construction néo-brunswickoise. Un grand nombre de structures en pierre du Nouveau-Brunswick sont encore debout partout dans l'est de l'Amérique du Nord, et, parmi elles, plus d'une centaine se trouvent dans notre propre province. Cependant, l'industrie de la pierre comme telle s'est considérablement affaiblie, son vibrant et romanesque passé étant aussi peu connu que son présent respectable ou, pour le moins, modeste. Quelques entreprises d'exploitation de carrières de pierres sont encore actives dans la province, tandis que d'autres produisent de la pierre locale ou importée destinée à la restauration, aux monuments et aux paysages urbains.

«*For Love of Stone*» est publié en deux volumes. Le volume I, compte rendu détaillé de l'industrie de la pierre au cours des ans — ses origines et son essor, sa décadence et son effondrement, son avenir potentiel — décrit quelques-unes des personnes qui ont contribué à faire connaître la pierre du Nouveau-Brunswick. Le volume II est un aperçu ou un catalogue de bâtiments ou de structures en pierre sélectionnés de la province. Il complète le volume I et sert de texte de référence indépendant aux concepteurs, aux planificateurs de patrimoine et aux autres personnes à la recherche de renseignements sur l'architecture en pierre de la province.

BEDROCK AGGREGATE STUDIES PROJECT[26]

D.V. Venugopal
Nonmetallic Minerals Geologist

and

T.C. Webb
Industrial Minerals Geologist

During the last decade or so, bedrock aggregate has become an increasingly important resource commodity in the road-building and construction industry and the demand for high-specification aggregate for the export market has shown an upward trend. The sustained increase in demand for bedrock aggregate is due to one or more of the following factors: 1) dwindling reserves of good-quality granular aggregate; 2) higher transportation costs; 3) demand for higher quality aggregate for construction of highways required to carry increasing volumes of high axle load traffic; 4) use of high-strength portland cement requiring high-specification aggregate; and 5) sterilization of areas in close proximity to urban centres and waterways due to social and environmental concerns.

A lack of province-wide information pertaining to bedrock aggregate during the last decade prompted the initiation of a program to establish a database of potential bedrock aggregate. In this regard, a pilot project was carried out under the previous Mineral Development Agreement, which included a preliminary regional evaluation of bedrock aggregate in selected parts of the Province (Figure 33). High-demand and high-density activity are among the criteria for the selection of the above areas. The study included a historical review of production and consumption statistics of bedrock aggregate, sampling of 80 sites, and engineering tests for the evaluation of the quality of high-specification aggregate.

The success of the initial project and persistant demand for high-quality aggregate led the Mineral Development Branch to extend the bedrock aggregate studies in a systematic manner on a Province-wide scale. Between 1989 and 1991, 280 sample sites covering about 18 NTS (1:50 000) sheets, were examined and samples collected (Figure 33). About 140 samples have been tested for their engineering quality according to American Standards Testing Methods (ASTM); of these, some 80 samples have been tested by the New Brunswick Department of Transportation (NBDOT). In order to carry out tests in an efficient manner, an in-house quality testing laboratory has been set up. The laboratory, operated by the Branch's Process Engineering section on a cost-sharing basis, is performing standard ASTM tests for size gradation, density, soundness, and the Los Angeles abrasion. The results are being compiled for interim report(s). The ultimate aim of this project is to produce an atlas that includes information pertaining to potential source(s) and quality of bedrock aggregate.

Within the broad framework and mandate of this project, about 15 per cent of time and effort is being spent on inquiries from private and other government agencies pertaining to bedrock aggregate throughout the Province. Any one or more of these inquiries involved from a mere one-half day consultation and advice pertaining to an aggregate deposit to several days of detailed research, aerial photograph, geological, and geophysical interpretation followed by various types of field investigations such as geological traversing, pit geology, and drill-core examination and interpretation. Among the external inquiries and consultation, work for the NBDOT is the most significant. Figure 34 shows approximate locations of areas being investigated.

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[26]There has been an increase in demand for bedrock aggregate over the past three years. The objective of this project is to establish a database of potential bedrock aggregate.

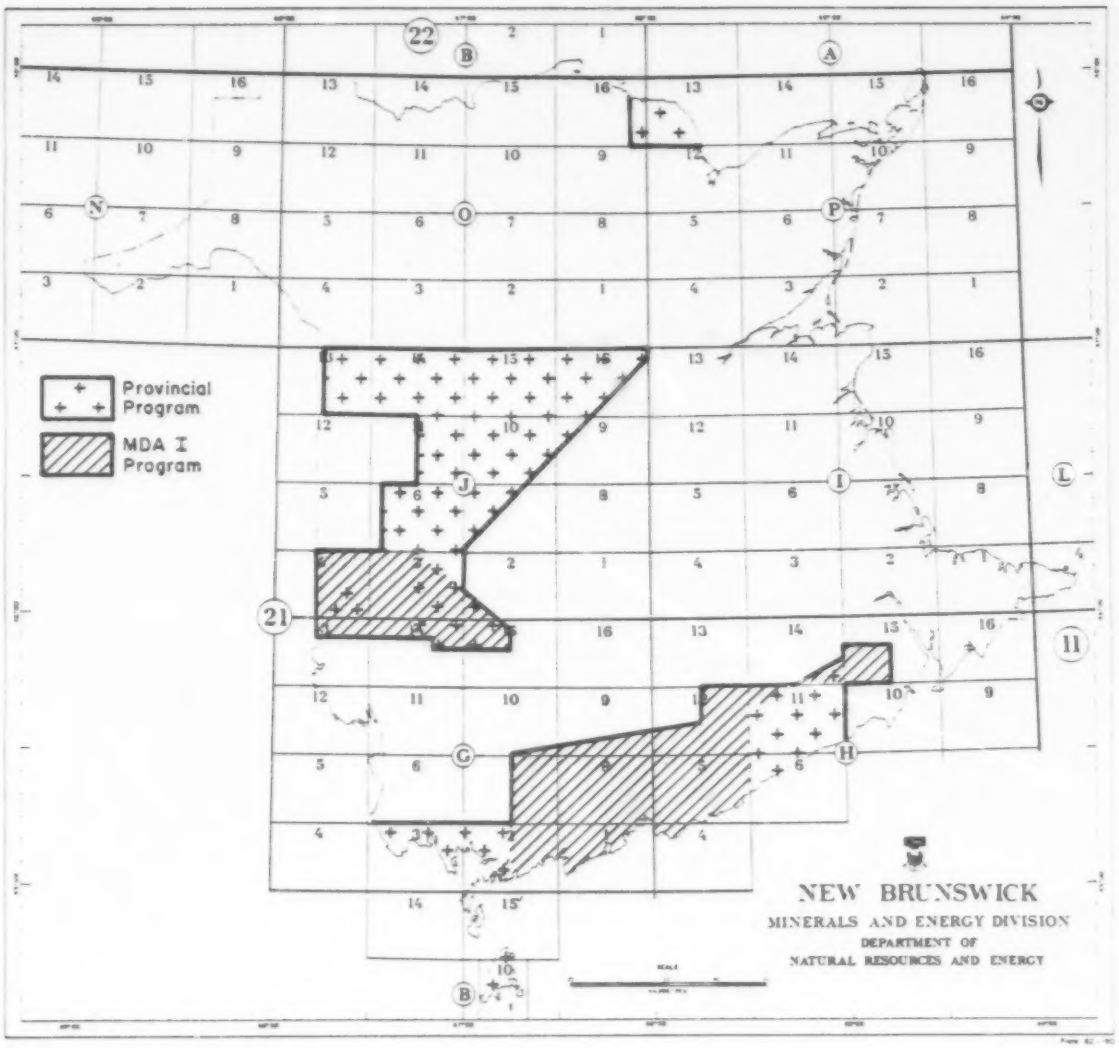

FIGURE 33. Bedrock aggregate study.

FIGURE 34. Location of area(s) of bedrock aggregate study for the Provincial Department of Transportation (NBDOT).

PROJET DES ÉTUDES D'AGRÉGATS DU SUBSTRAT ROCHEUX

D.V. Venugopal
Géologue des minerais non métalliques

et

T.C. Webb
Géologue (minerais industriels)

Au cours de la dernière décennie à peu près, les agrégats de substrat rocheux sont devenus une ressource de plus en plus importante dans l'industrie du bâtiment et de la construction des routes, et la demande d'agrégats de qualité supérieure destinés à l'exportation s'est accentuée. L'augmentation soutenue de la demande d'agrégats de substrat rocheux est redevable à l'un ou plusieurs des facteurs suivants : 1) la diminution des réserves d'agrégats granulaires de bonne qualité; 2) l'augmentation des coûts de transport; 3) la demande des agrégats de meilleure qualité pour la construction d'autoroutes nécessaires pour supporter des volumes croissants de poids lourds à essieux élevés; 4) l'utilisation de ciment Portland à haute résistance nécessitant des agrégats de qualité supérieure; 5) la stérilisation des secteurs à proximité des centres urbains et des cours d'eau en raison de préoccupations sociales et environnementales.

Un manque d'information à l'échelle provinciale au sujet des agrégats de substrat rocheux au cours de la dernière décennie a provoqué l'amorce d'un programme visant à établir une base de données des agrégats rocheux possibles. Un projet pilote a été entrepris à cet effet, dans le cadre de l'ancienne Entente sur l'exploitation minérale, qui prévoyait une évaluation régionale préliminaire des agrégats rocheux dans certaines régions sélectionnées de la province (Figure 33). L'importance de la densité et de la demande figurent parmi les critères de sélection des régions précitées. L'étude a compris une étude historique des statistiques sur la production et la consommation des agrégats rocheux, l'échantillonnage de 80 emplacements et des épreuves techniques pour l'évaluation de la qualité des agrégats de qualité supérieure.

La réussite du projet initial et la demande persistante d'agrégats de qualité supérieure ont poussé la Direction le l'exploitation des ressources minières à étendre les études sur les agrégats rocheux de façon systématique à l'échelle provinciale. Entre 1989 et 1991, 280 emplacements d'échantillonnage couvrant environ 18 feuilles SNRC (1/50 000) ont été examinés et des échantillons ont été prélevés (Figure 33). Environ 140 échantillons ont été soumis à des épreuves de qualité technique conformément aux American Standards Testing Methods (ASTM); parmi ceux-ci, quelque 80 échantillons ont été soumis aux tests du ministère des Transports du Nouveau-Brunswick. Pour effectuer ces tests de façon efficace, on a mis sur pied un laboratoire interne de vérification de la qualité. Le laboratoire, sous la section de l'ingénierie du traitement des minerais et du sol de la Direction sur une base de partage des frais, réalise les tests ASTM normaux sur le classement granulométrique, la densité, la stabilité et l'usure au rattler. On compile présentement les résultats en vue de préparer des rapports intérimaires. Le but ultime de ce projet est de rédiger un atlas comprenant des renseignements sur les sources potentielles et la qualité des agrégats rocheux.

En vertu du cadre d'action et du mandat de ce projet, environ 15 pour 100 du temps et des efforts sont consacrés aux demandes de renseignements provenant du secteur privé et des autres organismes gouvernementaux au sujet des agrégats rocheux partout dans la province. Chacune de ces demandes peut exiger entre une simple demi-journée de consultation et de conseils au sujet d'un gisement d'agrégats et plusieurs jours de recherches approfondies, de photographie aérienne, d'interprétation géologique et géophysique, suivies de divers types d'études sur le terrain comme la polygonation géologique, la géologie des carrières et l'interprétation et l'examen d'une carotte de sondage. Les travaux au service du ministère des Transports du Nouveau-Brunswick représentent la plus importante part des demandes et de la consultation de l'extérieur. La figure 34 montre les emplacements approximatifs des secteurs étudiés.

PEAT AND COASTAL ZONE RESOURCES

Jacques J. Thibault
Geologist

PEAT[27]

The following projects were being carried out in 1991:

1. **Peat Siltation Ponds.**

The objective of this project is to design, supervise the installation of, and monitor the effectiveness of siltation ponds for two peat-bog operations in the Lamèque area, northeastern New Brunswick. The project was awarded to Gemtec Limited of Fredericton, with technical assistance from the Peat Research and Development Centre of Shippagan. Two peat companies are actively participating in the project: Fisons Horticulture Inc. and Acadian Peat Moss (1979) Ltd. Results of the project are expected to be published in 1992, after one full year of monitoring. Funding for the project is cost-shared between the peat companies and the Mineral Resources Division (C-NBCAMD).

2. **Peatland Restoration.**

Over the next three years, it is proposed to test and evaluate selected restoration techniques for abandoned commercial peat extraction operations. The objective of the project is to develop restoration guidelines. The principal activities in 1991 consist of preliminary field investigations and preparation of terms of reference for the study. The project is funded under the C-NBCAMD.

3. **Peat Moss for Wastewater Treatment.**

The objective of the project is to demonstrate the effectiveness of peat moss filter beds for the treatment of domestic wastewater. The principal advantage of these systems is to provide a safe method of treatment of wastewaters in situations where conventional septic systems cannot be installed because of unsuitable soil conditions or space limitations. Peat beds will be constructed at four sites and monitored for twelve months. The project is sponsored by the Department of Natural Resources and Energy and funded under the Environmental Trust Fund. It is being carried out by the Peat Research and Development Centre, Shippagan, with representatives of the departments of Health and Community Services and of the Environment acting as technical advisors to the project.

COASTAL ZONE[28]

Mr. Dominique Bérubé was responsible for the 1991 field program that covered 60 km of coastline between Cape Tormentine and Shediac Harbour. Summary reports and maps (1:10 000 scale) describing the aspect of the shoreline and intertidal area will be published early in 1992. Figure 35 shows map coverage available or in preparation.

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[27]The purpose of Projects 1 and 2 is to study approaches that will mitigate the impact of bog development on water quality and the environment in general. The purpose of Project 3 is to develop new markets for more humified peat and extend the life of present operations.

[28]This project is funded by the Mineral Development Branch and carried out by the regular staff. The purpose is to produce a series of 1:10 000 geomorphological maps covering the entire marine coast of the Province, in support of an integrated approach to coastal zone management.

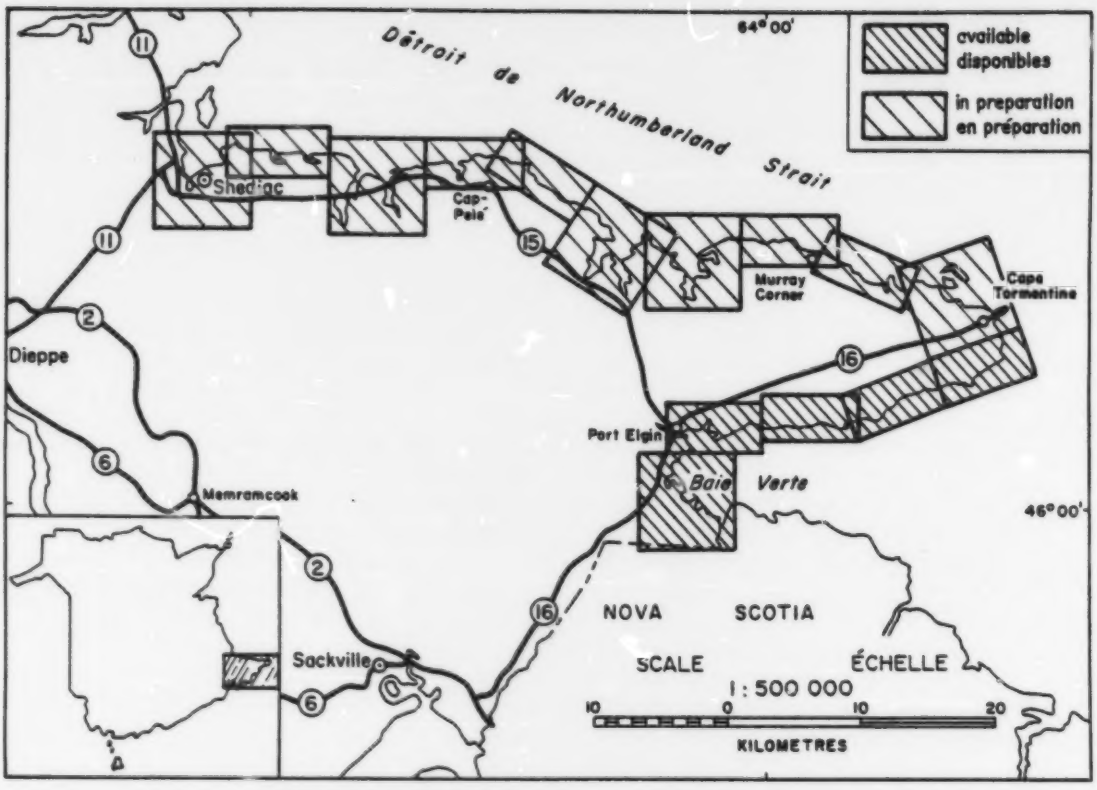

FIGURE 35. Coastal mapping project/Projet de cartographie littorale.

A paper entitled "Cartographie des milieux littoraux de la côte nord et est du Nouveau-Brunswick" was presented by Mr. Dominique Bérubé at the Annual Meeting of AQQUA (Association québécoise pour l'étude du Quaternaire), held last March in Montréal. The paper summarized the scope and objectives of Mineral Resources' coastal mapping program.

TOURBE ET RESSOURCES LITTORALES

TOURBE

En 1991, trois projets ont été mis à exécution:

1. **Bassins de sédimentation pour tourbières.**

L'objectif de ce projet est de préparer les plans, de superviser la construction et de contrôler l'efficacité et le rendement de bassins de rétention pour deux tourbières situées dans la région de Lamèque, au nord-est du Nouveau-Brunswick. Le projet a été confié à Gemtec Ltd. de Fredericton, avec l'assistance technique du Centre de Recherche et de Développement de la Tourbe de Shippagan. Deux compagnies de tourbe participent au projet: Fisons Horticulture Inc. et La Mousse Acadienne (1979) Ltée. On prévoit publier les résultats du projet en 1992, après une année complète de surveillance et de contrôle. Le projet est financé conjointement par les compagnies de tourbe et par la direction des ressources minérales (Entente de coopération Canada - Nouveau-Brunswick sur l'exploitation minérale).

2. Restoration de tourbières.

Au cours des trois prochaines années, l'on mettra à l'essai différentes méthodes de restoration afin d'aider à élaborer des lignes directrices concernant les conditions d'abandon des tourbières commerciales. En 1991, on procédera à quelques enquêtes sur le terrain ainsi qu'à la préparation des termes de référence. Le projet est financé dans le cadre de l'Entente de coopération Canada - Nouveau-Brunswick sur l'exploitation minérale.

3. Traitement des eaux usées par la tourbe.

Ce projet a pour but de démontrer l'efficacité de la tourbe comme agent de traitement des eaux domestiques usées. Le principal avantage de ce système est de procurer une méthode alternative de traitement lorsque les sols ou les dimensions du terrain ne permettent pas l'installation d'un système conventionnel. Quatre sites seront équipés d'un système à base de tourbe et surveillés pendant une période de douze mois. Le projet est parrainé par le ministère des Ressources naturelles et de l'Energie et financé par le Fonds de fiducie pour l'environnement. Le Centre de Recherche et de Développement de la Tourbe, Shippagan, a été chargé de l'exécution du projet. Des représentants des ministères de la Santé et des Services communautaires et de l'Environnement assureront le suivi technique.

ZONE LITTORALE

M. Dominique Bérubé assume la responsabilité du travail de terrain. Cet été, un secteur littoral de 60 km a été couvert, allant du cap Tourmentine à la baie de Shédiac. L'information recueillie sera publiée en 1992 sous la forme de rapports sommaires et de cartes à l'échelle 1:10 000. La figure 35 montre la couverture cartographique présentement disponible ou en voie de préparation.

Un exposé intitulé "Cartographie des milieux littoraux de la côte nord et est du Nouveau-Brunswick" a été présentée par M. Bérubé lors de la rencontre annuelle de l'AQQUA (Association québécoise pour l'étude du Quaternaire), tenue à Montréal au mois de mars 1991. L'exposé a fait état des buts et objectifs du nouveau programme de cartographie de la division des ressources minérales.

MINERAL DEVELOPMENT BRANCH

PROCESS ENGINEERING SECTION

PROCESS ENGINEERING (PROV & C-NBCAMD)[29, 30]

R. Harris
Process Engineer

and

D. Plante
Project Engineer (C-NBCAMD)

The process engineering sector was involved in many process and other related activities over the year. These included a review of technologies for further processing of base metals in the Province, a study of the conversion of BM&S' waste phosphogypsum to potassium sulphate and calcium chloride, and a preliminary evaluation of Supported Liquid Membranes for heavy-metal recovery. Other activities included the initiation of a study to assess options for the processing base-metal tailings and the administration of the Mineral Investment Stimulation and Mineral Processing Investigations programs. Three MISP contracts have been approved in 1991 to date.

Le secteur de l'ingénierie du traitement des minerais et du sol a été engagé dans de nombreux procédés et autres activités connexes au cours de l'année. Il a notamment réalisé une étude des technologies en vue d'une transformation plus poussée des métaux communs dans la province, une étude sur la conversion des déchets de phosphogypse de la Brunswick Mines and Smelting en sulfate de potassium et en chlorure de calcium, ainsi qu'une évaluation préliminaire des membranes liquides pour la récupération des métaux lourds. Parmi les autres activités, il a amorcé une étude pour évaluer les options en vue du traitement des résidus de métaux communs et il a administré le programme d'incitation à l'investissement dans le secteur des minéraux et le programme d'évaluation des possibilités de traitement des minéraux. On a approuvé à ce jour, en 1991, trois contrats du PIIM.

Several projects that were carried out over the past year, involved the process engineering sector. They were funded either under the A-base Provincial budget or the Canada-New Brunswick Cooperative Agreement on Mineral Development (C-NBCAMD); and are summarized as follows:

1. Technology review of further base-metal processing (A-base)

A review was undertaken of lead/zinc base-metal processing technology to identify those processing options that may have application to New Brunswick. As well, a preliminary technical and economic comparison of the most promising processing options was completed. This formed part of an inter-departmental study addressing the opportunities and constraints for a new zinc plant for the Province.

The Sherritt Gordon pressure leach and the developing CANMET ferric chloride leach processes were identified as having good potential for in-Province application. These are hydrometallurgical processes and were compared to conventional roast leach electrowin for the treatment of bulk and selective zinc concentrates, respectively. Both pressure leach and ferric chloride offer increased recovery possibilities while avoiding the generation of sulphur dioxide, which is typical of conventional pyrometallurgical smelters.

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[29]The Process Engineering Section has the objective to promote the development of further processing in the Province through the operation of a bench-scale laboratory, review of new technology encompassing mineral beneficiation and smelting, and the formulation and management of projects under the C-NBCAMD.

[30]Contribution to the Canada - New Brunswick Cooperation Agreement on Mineral Development, 1990-95. Project carried by the Geological Surveys Branch of the New Brunswick Department of Natural Resources and Energy. The Mineral Investment Stimulation Program is aimed at stimulating growth of the private sector through the implementation of cost-shared development projects.

2. Supported Liquid Membranes (A-Base)

This study was initiated in 1990 and completed in 1991. It was carried out by R. May & Associates of Fredericton, utilizing NBDNRE's laboratory facilities.

Supported liquid membranes (SLM) are a relatively new technology and are used to remove dissolved species from process streams. In principle, it is quite similar to conventional solvent extraction. The primary difference is that the SLM cells have permeable membranes through which molecular transfer is achieved with minimal mixing of the organic and aqueous phases/process streams. This approach was offered as a possible way of recovering dissolved base metals (*e.g.*, zinc) from tailing streams. A laboratory test unit was leased for this purpose using plant effluent from Heath Steele mines. The final report will be available soon as an Open File Report.

3. Mineral Investment Stimulation Program (MISP) (C-NBCAMD)

The objective of MISP is to provide financial assistance to the New Brunswick mineral industry to promote further development of the industry. The program was initiated under the previous Canada-New Brunswick Mineral Development Agreement (1984-89) and is being continued under the C-NBCAMD.

Five projects have been formally approved since the signing of the C-NBCAMD in 1990. Three projects have been approved to date in this fiscal year. The first involves a laboratory investigation of ferric chloride leaching of St. Stephen Nickel/Copper ore. This investigation ultimately led to the commissioning of a mini-pilot plant on the process. Another project involved the geological investigation of Boudreau (Sandstone) Quarry. This project was to determine the quality and quantity of stone available. The results were positive and a follow-up project is proposed to test alternative extraction methods. During this time, stone from the quarry has been sold for restoration work. The other project involves the commissioning of a pilot plant to investigate the feasibility of recovering waste coal material in the Grand Lake basin. Positive results could lead to the establishment of a commercial facility so that an otherwise wasted resource could be utilized. This processing method might also prove to be an effective way to deal with the environmental problem posed by the waste piles.

4. Assessment of Treatment Options for Base-Metal Sulphide Tailings (C-NBCAMD)

This is a proposed study for 1991 and will examine the merits of reprocessing the huge inventory of base-metal tailings in the Province for increased resource utilization and to address the looming environmental concerns. This is being proposed as an alternative to using covers and long-term water treatment practices.

5. Mineral Processing Investigations Program (C-NBCAMD)

The work program for this year consists of two studies; potassium sulphate manufacture using BM&S' waste phosphogypsum (began in 1990) and Sewell Brook zinc/lead beneficiation. Both studies require laboratory testing, which is being carried out in the mineral processing laboratory of the Mineral Resources Division.

For the phosphogypsum study, test work to date investigated the reaction of potash with phosphogypsum in an aqueous ammonia solution to form potassium sulphate and calcium chloride. The test results showed that good chemical conversions can be achieved but that the maximum grade attainable was largely affected by the insolubles content of the phosphogypsum and the formation of syngenite. The final report should be complete by year's end.

The Sewell Brook study began in April, 1991. Grinding and flotation test work is continuing to determine the basic beneficiation properties of this material for lead and zinc recovery. This work complements our geological efforts concentrated on the Sewell Brook area, which forms part of the Siluro-Devonian belt extending from Chaleur Bay to Plaster Rock.

NOTES

MINERAL DEVELOPMENT BRANCH

MINE ENGINEERING SECTION

MINE ENGINEERING[31]

S. McEwan
Mining Engineer

Mine development in New Brunswick during 1990/91 has been very limited with metal prices far below those of the previous year, and it is expected that price recovery will be slow during 1991/92. The following is a summary of mine-development–related activity for the 1990/91 period to date:

Stratabound Minerals Corp. (Captain North Extension - CNE):

Following the successful milling of their bulk sample at Heath Steele Mines in September of 1990, Stratabound Minerals embarked on a feasibility study to confirm the economic viability of the CNE deposit. At the same time the mine approval process was started, as well as discussions with Heath Steele on a potential contract for any future production from the CNE property. The deposit was ready for production by August, 1991. A successful agreement was arrived at with Heath Steele for the sale of their ore and the company received their Mining Lease and other required permits during the same period. Approximately 15 000 tons was mined in September for shipment to Heath Steele from the CNE north pit; subsequent mining will be based on the Heath Steele mill's production schedule and capacity requirements. Mining life of the deposit will depend on the rate at which Heath Steele processes the ore and any future extension of reserves at the CNE site. It is presently expected to be about 2 years at an average mining rate of 200 - 300 tons per day. The pit contains reserve of 228 812 tonnes averaging 7.38% zinc, 2.76% lead, and 2.68 oz. silver per ton, based on a cutoff grade of 8% combined lead-zinc.

Stratabound has entered into an exploration/joint venture agreement with Tech Corporation, which will include all of Stratabound's New Brunswick properties except the CNE open pit. In return for the right to earn 51% interest in these properties, Tech has agreed to spend $3 million on exploration over four years and pay Stratabound $50 000 on signing. Tech will also purchase $87 500 worth of Stratabound shares on each of the three anniversary dates after the deal is signed and $200 000 on the fourth anniversary. In exercising this option there is a minimum progressive price ($2.00, $2.25, $2.50, and $2.75 respectively on each of the anniversary dates) that Tech must pay for each share or else the current market price, whichever is greater. Tech must also spend a minimum of $300 000 in the first year of the agreement and $250 000 in each subsequent year. The total of $3 000 000 must be spent by the end of the agreement or else the properties revert back to Stratabound with no compensation to Tech. In addition to the CNE property, the other properties include Taylor Brook, Stratmat West, and Stratmat North.

Marshall Minerals Corp. (Restigouche Deposit)

Marshall Minerals completed their EIA Report for the Restigouche project and subsequently received a positive response, in August 1990, from the Lieutenant Governor in Council to proceed in the development of the project. A security of $1.6 million will be required to ensure the environmental integrity of the operation.

As the deposit is not large enough to support a mill, the company had hoped to enter into an agreement with a local mill to process the Restigouche ore. It is expected that it would cost in the range of $3 million to bring the property into production, and that production would run at about 1500 mtpd from an open-pit operation and employ about 50 people over 4 years. Marshall has proceeded no further than the EIA approval in their acquisition of other required government approvals and has put the deposit up for sale. The extensive delay associated with the EIA process (17 months) combined with the sharp downturn in zinc prices, as well as the closure of the Caribou operation, motivated Marshall to concentrate more effort on the development of properties outside the Province.

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[31]The Mine Engineer is responsible for reviewing mine feasibility reports for lease applications and for monitoring mining operations with respect to costs, markets, work force, and changes in mining schedules.

Heath Steele Mines (a division of Brunswick Mining & Smelting Corp. Ltd.)

Heath Steele completed its review of the economic feasibility of developing the C-Zone in January of 1991 and received conditional approval from the Board of Directors to proceed with Phase I of the project. Phase I consists of dewatering the A-Pit and rehabilitation of the ramp connecting the A-Pit to the new C-Zone and conducting underground exploration. Depending on the results of Phase I, the C-Zone could be accessed further by rehabilitating the 400 metre No. 4 Shaft. To date, 1.85 million tonnes of 7.6% zinc and 1.5% lead has been outlined in the C-Zone with good potential for more. The development of the C-Zone will mean an extended mine life to seven years from the current five. Phase I is expected to cost $4.0 million with actual development (Phase II) to be in the $16.0 million range. Noranda is actively seeking a partner to enter into a joint venture to fund the Phase II portion of the plan and have actually stated that they may consider selling the entire Heath Steele property if the price is right.

In conjunction with this expansion in production, an EIA screening was performed with subsequent approval conditional to the posting of a $6.1 million rehabilitation security. This security has been posted and work at the C-Zone is proceeding. Heath Steele experienced another unfortunate environmental event in February, when a pipe carrying contaminated mine water ruptured and spilled into the Little South Tomogonops River. Heath Steele embarked on a process to determine the impact of the spill on the river and its fish population, as well as taking steps to ensure that it does not happen again. They were taken to court over the incident by the Department of Environment and fined $30 000.

In spite of the fact that Heath Steele is a wholly owned subsidiary of Brunswick mining & Smelting Corp. Ltd., the extended strike at BM&S did not affect the company and union from reaching a satisfactory agreement. Workers will receive an average increase of 21% over a 37.5 month contract commencing on November 14, 1990 and ending December 31, 1993.

Murray Brook Resources Ltd. (a wholly owned subsidiary of NovaGold Resources Ltd.)

Murray Brook continued to produce at rated design capacity through 1990 and by year end had generated 16 514 oz. of gold and 81 126 oz. of silver. As previously stated, initial recoveries were in excess of design, however, cold ore in the winter months did affect recoveries in the extraction process with recoveries in the order of 50% for the months of January and February. Murray Brook reviewed in conjunction with the Provincial government, the possibility of an ore preheater to overcome this problem and following positive test results installed an ore preheater. This has resulted in winter recoveries similar to the warmer months of the year, in the 85% range.

NovaGold began looking at the feasibility of processing the copper portion of the Murray Brook deposit using the ferric chloride leach process (FCL). This initial study was done with the assistance of CANMET and results proved very promising so much so that NovaGold has entered into an agreement with CANMET to acquire a licence for the process for use in New Brunswick and the Northwest Territories. FCL is an advanced technology for the efficient recovery of non-ferrous metals from sulphide base-metal ore that can potentially increase metal recoveries and revenues significantly. It also has the capability to produce a finished metal as its final product, thus eliminating the environmentally undesirable smelting aspect of metal processing. NovaGold is currently striving toward the creation of a demonstration plant for the process and has initiated an engineering cost study for a demonstration plant in New Brunswick. Estimated costs for such a plant are in the range of $45 million.

East West Caribou Mining Ltd.

East West Caribou Mining has seen limited activity since the suspension of operations on October 26, 1990. The site has been maintained by a complement of 15 employees ensuring the infrastructure is preserved for immediate start-up, as well as assuring the environmental integrity of any effluent leaving the site. The property is for sale and the parent company Breakwater Resources Ltd. is actively seeking a potential buyer. A number of interested parties have looked at the site but no serious offers have been received to date.

GÉNIE MINIER

S. McEwan
Ingénieur minier

L'exploitation minière au Nouveau-Brunswick a été très limitée en 1990-1991, avec une baisse du cours des métaux bien au-dessous du niveau de l'année précédente, et on s'attend à ce que la reprise du cours soit lente au cours de 1991-1992. Voici un sommaire de l'activité reliée à l'exploitation minière pour la période de 1990-1991 à ce jour.

Stratabound Minerals Corp. (Captain North Extension - CNE)

Après son succès dans le broyage de son échantillon global à la Heath Steele Mines en septembre 1990, la Stratabound Minerals a entrepris une étude de faisabilité en vue de confirmer la viabilité économique du gisement CNE. En même temps, le processus d'approbation minière a été amorcé, et des pourparlers ont été engagés avec la Heath Steele Mines à propos d'un important contrat portant sur toute production future du gisement CNE. Le gisement était prêt pour la production en août 1991. Une entente est intervenue avec la Heath Steele Mines au sujet de la vente de son minerai et la société a obtenu son bail d'exploitation minière et les autres permis requis au cours de la même période. Environ 15 000 tonnes ont été extraites en septembre pour être expédiées de la mine à ciel ouvert nord de CNE à la Heath Steele Mines; l'exploitation future sera basée sur les exigences du point de vue de l'ordonnancement et de la capacité de production. La période d'exploitation dépendra du rythme auquel la Heath Steele Mines traitera le minerai et toute extension future des réserves à la mine à ciel ouvert de CNE. On s'attend actuellement à une exploitation d'environ deux ans à un débit d'exploitation moyen de 200-300 tonnes par jour. Le gisement contient une réserve de 228 812 tonnes d'une teneur moyenne en zinc de 7,38 %; en plomb, de 2,76 %; en argent, de 2,68 oz/t, selon une teneur limite de 8 % en plomb-zinc combinés.

La Stratabound a signé un contrat d'exploration d'entreprise conjointe avec la Tech Corporation, qui inclura toutes les propriétés de la Stratabound au Nouveau-Brunswick à l'exception de la mine à ciel ouvert de CNE. En échange du droit de prélever un intérêt de 51 % sur ces propriétés, la Tech Corporation s'est engagée à investir trois millions de dollars dans l'exploration sur une période de quatre ans, et à verser à la Stratabound la somme de 50 000 $ au moment de la signature du contrat. La Tech Corporation achètera en outre de la Stratabound des actions d'une valeur de 87 500 $ à chacun des trois premiers anniversaires après la signature du contrat, et de 200 000 $ au quatrième anniversaire. En exerçant cette option, la Tech Corporation versera pour chaque action un prix progressif minimal (2 $, 2,25 $, 2,50 $ et 2,75 $ respectivement à chaque date anniversaire) ou le prix du marché courant, selon le plus élevé des deux. La Tech Corporation doit également investir un minimum de 300 000 $ la première année du contrat et de 250 000 $ les années subséquentes. Une somme totale de 3 000 000 $ devra avoir été dépensée à la fin du contrat, sinon les propriétés reviendront à la Stratabound sans que celle-ci ne soit obligée de verser aucune compensation à la Tech. En plus de la propriété de CNE, les autres propriétés comprennent le ruisseau Taylor, Stratmat Ouest et Stratmat Nord.

Marshall Minerals Corp. (gisement de Restigouche)

La Marshall Minerals a terminé son rapport d'EIE pour le projet de Restigouche et, en août 1990, le lieutenant-gouverneur en conseil l'a autorisée à en entreprendre l'exploitation. Un cautionnement de 1 600 000 $ sera exigé afin d'assurer l'intégrité environnementale de l'exploitation.

Comme le gisement n'est pas assez important pour approvisionner une usine de concentration, la société comptait s'entendre avec une usine locale pour traiter le minerai de Restigouche. Les coûts de mise en exploitation de la propriété devraient atteindre 3 000 000 $. L'exploitation de la mine à ciel ouvert devrait permettre d'extraire 1 500 tonnes de minerai par jour et d'employer environ 50 personnes pendant quatre ans. La Marshall n'est pas allée plus loin que l'autorisation de l'EIE dans son obtention d'autres approbations du gouvernement, et elle a mis le gisement en vente. Le retard excessif associé au traitement de l'EIE (17 mois), la baisse vertigineuse des prix du zinc et la fermeture de l'exploitation de Caribou ont contribué à motiver la

Marshall à concentrer davantage d'efforts sur la mise en valeur de propriétés à l'extérieur de la province.

Heath Steele Mines (division de la Brunswick Mining and Smelting Corp. Limited)

La Heath Steele Mines a terminé son analyse de faisabilité économique de la mise en valeur de la Zone C, en janvier 1991, et elle a obtenu l'approbation conditionnelle du conseil d'administration de passer à la Phase I du projet. Cette phase consiste à assécher la mine A et à remettre en état la rampe reliant la mine A à la nouvelle Zone C, ainsi qu'à entreprendre des travaux d'exploration souterraine. Selon les résultats de la Phase I, la Zone C pourrait être accessible en remettant en état le puits n° 4 de 400 mètres. Il existe actuellement 1,85 millions de tonnes de minerai d'une teneur en zinc de 7,6 % et en plomb, de 1,5 %, dans la Zone C, avec un bon potentiel pour davantage. La mise en valeur de la Zone C signifiera une prolongation à sept ans de la période d'exploitation, actuellement fixée à cinq ans. La Phase I devrait coûter 4 000 000 $ et la mise en valeur réelle (Phase II) devrait coûter une somme de l'ordre de 16 000 000 $. La Noranda recherche activement un associé en vue de signer un contrat d'entreprise conjointe pour le financement la Phase II du plan et elle a, en fait, précisé qu'elle envisagerait de vendre la propriété entière de la Heath Steele si le prix lui convenait.

En même temps que cette expansion au niveau de la production, une sélection de l'EIE a été effectuée avec une approbation conditionnelle subséquente au dépôt d'un cautionnement de remise en état de 6 100 000 $. Ce cautionnement a été déposé et les travaux ont été amorcés dans la Zone C. La Heath Steele a connu un autre accident environnemental en février, lorsqu'une conduite transportant de l'eau d'exhaure contaminée s'est rompue et a causé un déversement dans la rivière Little South Tomogonops. La Heath Steele a réalisé une évaluation des effets du déversement sur la rivière et sur sa population de poissons et elle a pris les mesures nécessaires pour que cet accident ne se reproduise pas. Le ministère de l'Environnement a poursuivi la société en cour et elle a dû verser une amende de 30 000 $.

Bien que la Heath Steele soit une filiale en propriété exclusive de la Brunswick Mining and Smelting Corporation Ltd., la grève prolongée à la Brunswick n'a pas empêché la société et le syndicat d'en arriver à une entente satisfaisante. En effet, les travailleurs obtiendront une augmentation de 21 % étalée sur une période de 37,5 mois commençant le 14 novembre 1990 et finissant le 31 décembre 1993.

Murray Brook Resources Ltd., (filiale en propriété exclusive de la NovaGold Resources Ltd.)

La Murray Brook a continué à produire à sa capacité nominale en 1990 et, à la fin de l'année, elle avait produit 16 514 oz d'or et 81 126 oz d'argent. Comme il a été précédemment mentionné, les taux initiaux de récupération dépassaient les chiffres de capacité nominale, bien que le minerai froid durant les mois d'hiver (janvier et février) a réduit le taux de récupération du procédé d'extraction d'environ 50 %. La Murray Brook a étudié, avec la collaboration du gouvernement provincial, la possibilité d'utiliser un réchauffeur de minerai afin de résoudre le problème. Les résultats de l'étude s'étant avérés positifs, le réchauffeur de minerai a été installé. L'installation du réchauffeur a ainsi permis d'obtenir en hiver un taux de récupération analogue à celui des mois chauds, c'est-à-dire d'environ 85 %.

La NovaGold a commencé a étudier la faisabilité du traitement du cuivre du gisement de la Murray Brook à l'aide du procédé de lixiviation au chlrore ferrique (LCF). Cette étude préliminaire a été effectuée avec l'aide de CANMET, et les résultats se sont avérés très prometteurs, si bien que la NovaGold a signé une entente avec CANMET en vue d'obtenir un permis d'utilisation du procédé au Nouveau-Brunswick et dans les Territoires du Nord-Ouest. Le procédé LCF, technologie avancée pour la récupération efficace des métaux non ferreux du minerai de métaux communs sulfurés, permet d'accroître la récupération des métaux et les recettes de façon remarquable. Il permet également de produire un métal fini comme produit final, éliminant ainsi l'aspect indésirable pour l'environnement du traitement des métaux par la fusion. La NovaGold essaie en ce moment par tous les moyens de créer une usine-pilote en vue de la mise en application de ce procédé et elle a amorcé une analyse des coûts de conception aux fins de l'implantation de cette usine au Nouveau-Brunswick. Les coûts estimatifs de l'usine en question sont de l'ordre de 45 000 000 $.

East West Caribou Mining Ltd.

L'East West Caribou Mining a connu une activité restreinte depuis la suspension de ses opérations le 26 octobre 1990. Quinze employés ont assuré l'entretien de son infrastructure en vue d'une remise en activité immédiate, ainsi que l'intégrité environnementale de tout effluent quittant les lieux. La propriété est à vendre, et la société mère, la Breakwater Resources Ltd., recherche activement un acheteur éventuel. Un certain nombre d'intéressés ont visité la propriété, mais aucune offre sérieuse n'a encore été reçue.

MINE RECLAMATION[32]

R. Butler
Mine Reclamation Engineer

Through the New Brunswick Mining Act and its regulation, all developing mining operations are required to implement a program for the protection, reclamation, and rehabilitation of the environment. The reclamation plan is considered part of the Mine Feasibility Study and is developed during the initial design phase of a mining project. If the reclamation plan is properly engineered it may prevent major environmental impacts from occurring and will result in a mine site that is more readily rehabilitated at a much lower cost to the mining company.

In the administration of the Mining Act, mine reclamation engineering involves:

1) Inspection of existing mining operations in the Province; review of their reclamation practices; and technical support for reclamation programs.
2) The analysis and review of new mining projects in the Province; review of feasibility studies with emphasis on reclamation and rehabilitation; liaison between Natural Resources and Energy and the Department of Environment for assistance in the review of reclamation plans.

Since November 1990, the Stratabound Mineral Reclamation Plan has been approved. The Branch has also approved the Exploration Reclamation plans for Gordex silica deposit, Beersville Coal Project, and Brookville Manufacturing Lime Quarry near Ketepec.

Reclamation engineering also involves research into methods of alleviating the environmental impact of existing or closed mining operations. The main factors apparent at abandoned mine sites include; reactive acid tailings and mine rock, site safety, and general land rehabilitation.

The Province has representation on the Mine Environment Neutral Drainage (MEND) committee and provides financial and technical support through various Provincial reclamation programs. Provincial support was given to Brunswick Mining and Smelting to investigate the effect of capping acid-generating waste-rock piles at their Heath Steele Mines operation. The Province is also involved in a reclamation research program for abandoned Peatlands.

RÉAMÉNAGEMENT MINIER

R. Butler
ingénieur minier

Par l'entremise de la Loi sur les mines du Nouveau-Brunswick et de ses règlements, toutes les opérations minières présentement en développement doivent implanter un programme pour la protection, le réaménagement et la revitalisation de l'environnement. Le plan de réaménagement est considéré comme faisant partie de l'étude de faisabilité minière et est élaboré durant la phase de conception préliminaire d'un projet minier. Si le plan de réaménagement est bien conçu il pourra prévenir des problèmes environnementaux majeurs et resultera en un site minier plus apte à être revitalisé à un coût beaucoup moindre pour la compagnie minière.

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[32]The Mine Reclamation Engineer is responsible for ensuring that mine reclamation programs are submitted in accordance to the Mining Act and in monitoring the programs, as well as reviewing other projects su˚ nitted under the Environmental Impact Assessment regulations.

Dans l'administration de la Loi sur les mines, le réaménagement minier implique :

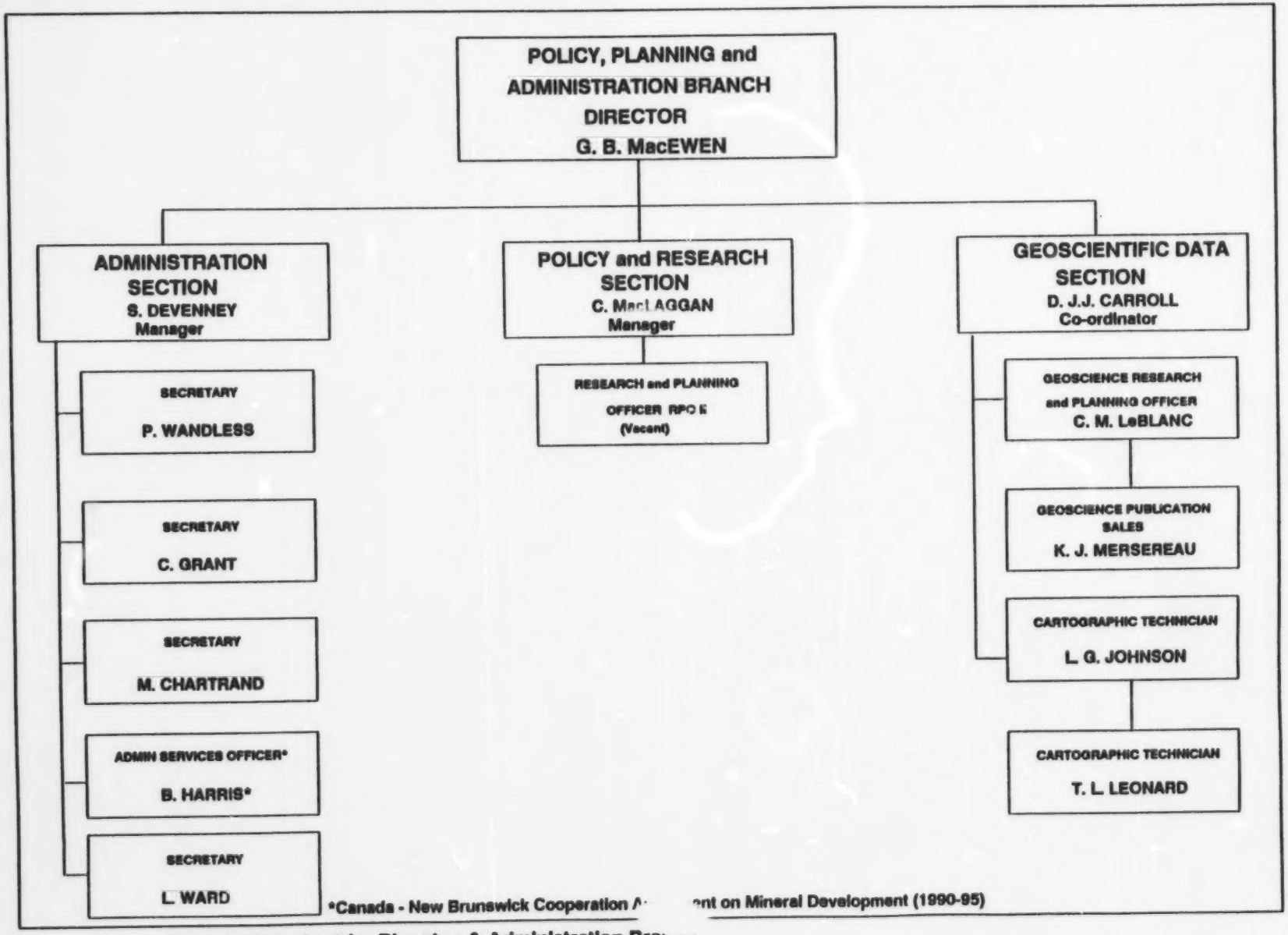
1) l'inspection des sites miniers en opération dans la province, l'examen des pratiques de réaménagement, et un soutien technique pour les programmes de réaménagement;
2) l'analyse et l'évaluation des nouveaux projets miniers dans la province, l'examen des études de faisabilité mettant l'accent sur le réaménagement et la revitalisation, et la liaison entre le ministère des Ressources naturelles et de l'Énergie et le ministère de l'Environnement pour obtenir une assistance dans l'évaluation des plans de réaménagement.

Le plan de récupération de la Stratabound Mineral est approuvé depuis novembre 1990. La Direction a également approuvé les plans d'exploration de récupération relatifs au gisement de silice de Gordex, au projet de charbon de Beersville et à la carrière de calcaire de la Brookville Manufacturing près de Ketepec.

Le réaménagement minier implique aussi de la recherche au niveau des méthodes visant à réduire l'impact environnemental aux sites miniers, opérationnels ou non. Les facteurs les plus manifestes aux sites de mines abandonnées incluent : les rejets de concentrateurs et les amas de stériles chimiquement actifs, la sécurité des sites et la revitalisation générale des terres environnantes.

La province est représentée au Comité de neutralisation des eaux et du drainage dans l'environnement minier (NEDEM) et fournit un soutien technique et financier par l'entremise de divers programmes provinciaux de réaménagement. Un support gouvernemental a été donné à Brunswick Mining and Smelting pour l'étude du développement des chapeaux de fer sur les amas de stériles chimiquement actifs à la mine de Heath Steele. La province est aussi impliquée dans un programme de recherche en réaménagement des tourbières abandonnées.

POLICY, PLANNING, AND ADMINISTRATION BRANCH



*Canada - New Brunswick Cooperation A· ·ent on Mineral Development (1990-95)

Organization chart for Planning & Administration Bran·

POLICY, PLANNING, AND ADMINISTRATION BRANCH

GEOSCIENCE DATA SECTION

ACTIVITIES OF THE GEOSCIENCE DATA SECTION

D.J.J. Carroll
Coordinator

The Geoscience Data Section consists of the following staff members: Donald J.J. Carroll (Coordinator), L. Gerard Johnson (Cartographic Technician), Terry Leonard (Cartographic Technician), Ken Mersereau (Geoscience Publication Sales), and Carol M. LeBlanc (Exploration Assessment Data).

The Section is responsible for providing a variety of geoscientific, technical, and support services to the staff of the Minerals and Energy Division. In addition, the staff of the Section provide assistance to the public, in particular the mineral industry, by supplying publications on the geology and mineral resources of the Province.

The Geoscience Data Section is made up of Geoscientific Cartographic Services and Geoscientific Information Services.

The distribution of geoscience publications from the Fredericton office in 1991 totalled 5303 maps and reports. The majority of these sales were to individuals working for the mineral exploration industry.

ACTIVITÉS DE LA SECTION DES DONNÉES GÉOSCIENTIFIQUES

D.J.J. Carroll
coordonnateur

La Section des données géoscientifiques comprend le personnel suivant : Donald J.J. Carroll (coordonnateur), L. Gerard Johnson (technicien de cartographie), Terry Leonard (technicien de cartographie), Ken Mersereau (vent des publications géoscientifiques) et Carol M. LeBlanc (évaluation des données d'exploration).

La Section doit fournir une foule de services géoscientifiques, techniques et de soutien au personnel de la Division des ressources minérales et de l'énergie. En outre, le personnel de la Section doit offrir au public, et plus particulièrement aux représentants de l'industrie minière, des publications portant sur la géologie et les ressources minérales de la province.

La Section des données géoscientifiques comprend les services de cartographie géoscientifique et les services d'information géoscientifique.

Au cours de l'année 1991, les publications géoscientifiques distribuées par le bureau de Fredericton ont totalisé 5303 cartes et rapports. La plupart des publications ont été vendues à des particuliers travaillant dans l'industrie de l'exploration minière.

PART II

GEOLOGICAL SURVEY OF CANADA

GEOLOGICAL MAPPING OF THE EASTERN CALEDONIAN HIGHLANDS, KINGS AND SAINT JOHN COUNTIES, SOUTHERN NEW BRUNSWICK (C-NBCAMD)[33]

S.M. Barr and C.E. White
Department of Geology, Acadia University, Wolfville, NS B0P 1X0

The eastern Caledonian Highlands were mapped during the summer of 1991, thus completing bedrock mapping of the Caledonian Highlands initiated in 1985. Both the older and younger sequences of Late Precambrian metavolcanic and metasedimentary rocks defined in the central Caledonian Highlands extend into the eastern Highlands. The same phyllite and schist unit that hosts the Teahan copper-zinc-lead sulphide deposit, hosts the Lumsden deposit in the eastern Highlands. Plutonic rocks constitute a major component of the eastern Caledonian Highlands; a previously unrecognized pluton underlies the central part of the map area and appears to be similar to ca. 615-625 Ma granodioritic plutons in the central Caledonian Highlands. Plutonic rocks elsewhere in the map area range in composition from gabbro to granite. Most geological contacts are faulted and all rock types are moderately to strongly sheared and commonly display protomylonitic textures.

Des travaux de cartographie ont été effectués au cours de l'été 1991 dans les collines calédoniennes orientales, ce qui a mis fin aux travaux de cartographie des dépôts rocheux des collines calédoniennes commencés en 1985. Les paragenèses, âgées et jeunes, des roches métavolcaniques et métasédimentaires du Précambrien supérieur, définies dans les collines calédoniennes centrales, s'étendent aux collines orientales. La même unité de phyllites et de schistes hôte du gisement sulfuré de cuivre-zinc-plomb de Teahan, contient le gisement de Lumsden des collines orientales. Les roches plutoniques constituent un élément important des collines calédoniennes orientales; un pluton précédemment méconnu repose à la base de la partie centrale de la région cartographiée et il s'avère similaire aux plutons granodioritiques d'environ 615-625 Ma des collines calédoniennes centrales. Ailleurs dans la zone cartographiée, les roches plutoniques ont une composition allant du gabbro au granit. La plupart des contacts géologiques comportent des failles, et tous les types de roches sont modérément à fortement cisaillés et présentent généralement des textures protomylonitiques.

INTRODUCTION

Pre-Carboniferous rocks of the eastern Caledonian Highlands (Figure 36) were mapped during June, 1991, thus completing geological mapping of the Caledonian Highlands initiated in 1985 (Barr 1987; Barr and White 1988*a*, 1988*b*, 1989, 1991). The field work showed that major units of the central Caledonian Highlands (Barr 1987; Barr and White 1989) extend through the eastern Highlands. Studies of the petrology and structural features of the map units are in progress, together with U-Pb dating of key units.

METAVOLCANIC-METASEDIMENTARY UNITS

Most of the eastern Caledonian Highlands appears to be underlain by metavolcanic and metasedimentary rocks that are part of the older sequence (sequence A) of Barr and White (1988*c*, 1989). These rocks have been subdivided into six major units (Figure 36). Two other units (Bbr and Bsd) appear to be correlative with the younger sequence B of Barr and White (1988*c*, 1989). Most of these units show effects of pervasive shearing and are protomylonitic. Most of the contacts are probably faulted, although we have not attempted to distinguish faulted from other types of contacts at the scale of Figure 36. Units along the northern margin of the map area are particularly sheared and mylonitic.

Unit Aph occupies the central part of the map area, and is the extension of Unit A2 of Barr and White (1989). The rocks are mainly strongly cleaved phyllites, chloritic schists, and slates, apparently developed from

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[33]Contribution to the Canada - New Brunswick Cooperation Agreement on Mineral Development, 1990-1995. Project carried by the Geological Survey of Canada.

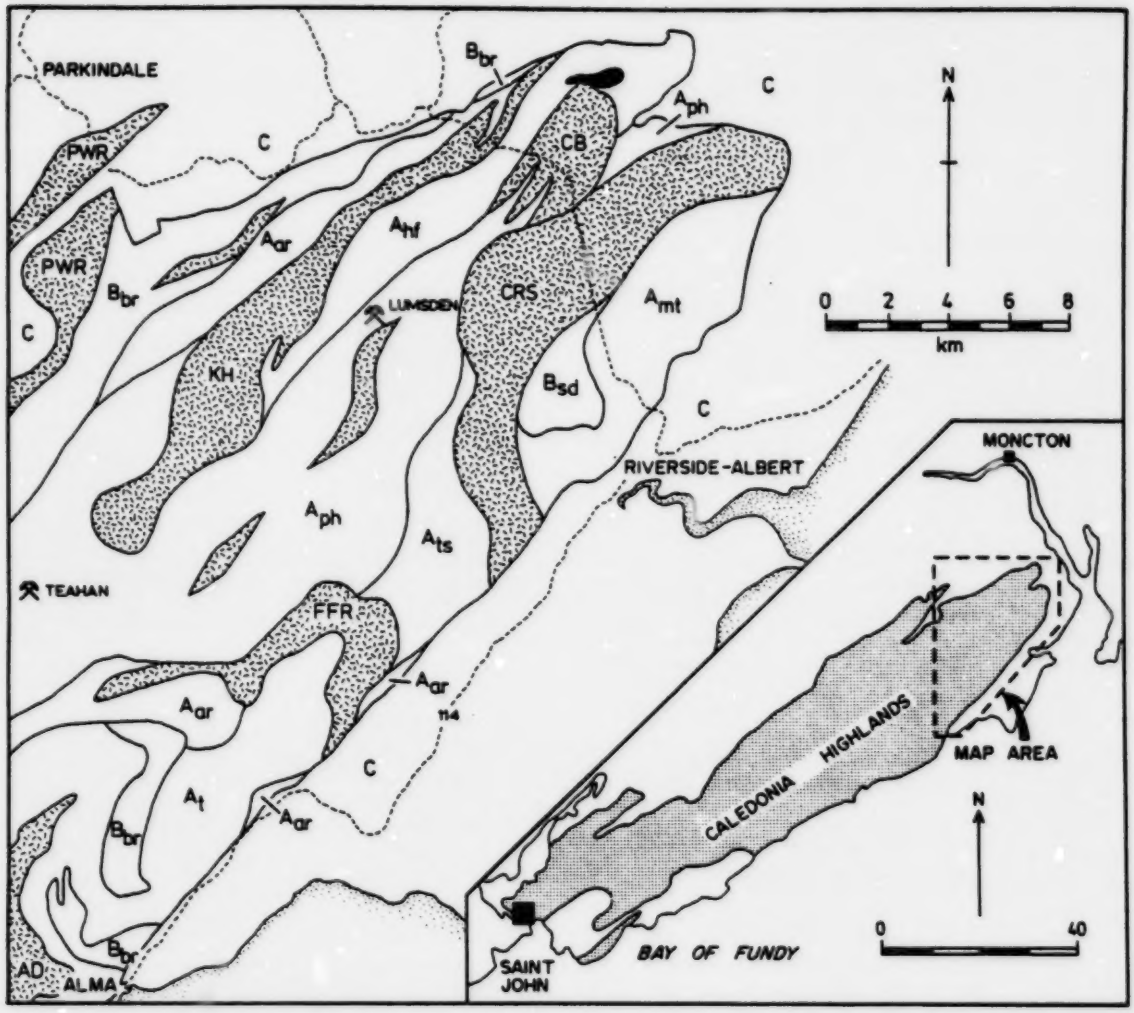

FIGURE 36. Simplified geological map of the eastern Caledonian Highlands showing the distribution of major metavolcanic/metasedimentary and plutonic units. Plutonic units are patterned. For clarity at this scale, faulted contacts and other faults are not shown. Locations of Teahan and Lumsden Cu-Pb-Zn deposits are shown by the crossed hammers symbol.

volcanogenic sedimentary protoliths. Although mainly of intermediate (dacitic to andesitic) composition, some layers are buff-coloured felsic sericitic schists, and mafic units are locally present. This unit hosts both the Teahan and Lumsden copper-zinc-lead sulphide deposits, described by Ruitenberg *et al.* (1979).

Unit Aar is a distinctive arkosic sedimentary unit that occurs both north and south of Unit Aph, and in several slivers faulted against Carboniferous rocks along the southern margin of the map area (Figure 36). It consists of buff to grey siltstone, sandstone, and conglomerate. The part of Unit Aar south of Unit Aph is the extension of Unit A3 of Barr and White (1989), and was termed the "Forty-Five River arkose" by Ruitenberg *et al.* (1979). In the northern part of the map area, the rocks tend to be strongly sheared and cleaved, like adjacent units. Younging directions in the Unit Aar, both north and south of Unit Aph, are consistent with the presence of an anticlinal structure.

Unit Ahf is located between Unit Aph and the Kent Hills pluton. It may be part of Unit Aph but is

LEGEND

CARBONIFEROUS

C	Horton and Windsor groups; Hopewell Group; Boss Point/Lancaster Formation

LATE PRECAMBRIAN OR YOUNGER

	Caledonia Mountain stock (gabbro)

LATE PRECAMBRIAN

	Plutonic rocks: PWR, Point Wolfe River Pluton; KH, Kent Hills granodiorite; CB, Caledonia Brook pluton; CRS, Caledonia Road granitoid suite; FFR, Fortyfive River granodiorite; AD, Alma dioritic pluton
B_{sd}	Grey to maroon slate and phyllite; arkosic siltstone and sandstone
B_{br}	Basaltic and rhyolitic flows and tuffs; amygdaloidal basalt; grey laminated siltstone
A_{mt}	Mafic crystal tuff, lithic tuff, and flows; interlayered volcanogenic sedimentary rocks
A_{t}	Dacitic crystal tuff and crystal-lithic tuff; pyritiferous felsite and felsic tuff
A_{ts}	Dacitic to andesitic crystal-lithic tuff; laminated grey-green siliceous siltstone
A_{hf}	Meta-siltstone, locally laminated.
A_{ar}	Buff to grey arkosic siltstone, sandstone, and conglomerate
A_{ph}	Phyllite, chloritic schist, slate

generally more massive, in part because of contact metamorphism from both the Kent Hills pluton and the Caledonia Mountain gabbro. In most places, the rocks are dark grey, locally laminated, meta-siltstones. In places, they appear more tuffaceous and/or arkosic. Locally they contain abundant pyrite.

Unit Ats is a large area of dacitic to andesitic crystal-lithic tuffs with minor, but distinctive, finely laminated, cleaved, grey to grey-green tuffaceous siltstone layers. Lithic fragments in the tuff are commonly light grey to buff-grey chert/siltstone and minor dark green amygdaloidal basalt. Mafic crystal tuffs and flows with chlorite patches occur rarely. The unit also contains abundant sheets of medium-grained, locally pegmatitic, red leucogranite and less abundant red-green diorite/granodiorite.

Unit At is a tuffaceous unit, the extension of Unit A6 of Barr and White (1989). It consists of light grey-green dacitic crystal and crystal-lithic tuff with abundant grey to buff pyritiferous felsite, felsic tuffs, and associated quartz veins. Lithic fragments are commonly pink and light grey chert/felsite. Green mafic crystal tuffs and flows are less common. Like Unit Ats, it contains granitoid (mainly red leucogranitic) bodies and minor andesitic porphyry sheets.

Unit Amt is composed mainly of mafic volcaniclastic rocks, with interlayered grey and pink-green laminated volcanogenic sedimentary rocks. Dark green amygdaloidal mafic flows with numerous epidote veins and pods are common. Pink felsite dykes, up to two metres in width, are present close to the contact with the Caledonia Road granitoid suite to the northwest. Overall, the rocks appear similar to those along the coast southwest of Alma (Unit A1 of Barr and White 1989) that host the Roman Wolfe, Vernon, and Mile Brook copper-vein deposits described by Ruitenberg *et al.* (1979).

Unit Bbr occurs along the northern margin of the map area, and consists of a complex assemblage of mafic and felsic flows, tuffs, and sheets, mainly very sheared and mylonitic. Much of this unit appears to be correlative with the amygdaloidal basalt Unit B3 and adjacent rhyolite Unit B2 described by Barr and White (1989). Amygdaloidal and other igneous textures are only rarely preserved in this part of the unit due to the effects of intense shearing and mylonitization. Laminated siltstones occur in slivers along the northern margin of this unit.

Unit Bsd occurs northwest of Riverside-Albert in the eastern part of the map area. It appears to lie unconformably on the older rocks of Unit Amt, and to be in faulted contact with plutonic rocks of the Caledonia Road granitoid suite, but all units in this area are strongly deformed, so field relations are not clear. These rocks are mainly grey to maroon slates and phyllites and variably cleaved maroon arkosic muscovite-bearing sandstones and siltstones, locally with cross-bedding and graded bedding. Minor, thin (<2 cm wide) rusty-brown carbonate layers and concretions are interbedded with the grey slates. Associated mafic rocks appear to be dykes or sills. On the basis of lithological similarities, these rocks may be correlative with Unit B1 of Barr and White (1989).

PLUTONIC ROCKS

Plutonic rocks, ranging in composition from gabbro to granite, are a major component of the eastern Caledonian Highlands. Several of these were identified and named by Ruitenberg *et al.* (1979), who considered them to be sills. However, most contacts appear to be faulted and the sill-like form of most of the larger plutons is probably the result of shearing and mylonitization after intrusion. Most of these plutonic rocks occur in mappable bodies; however, some of the metavolcanic-sedimentary units contain numerous sheets/dykes/sills that cannot be mapped out as separate units, and several small plutons cannot be shown on the scale of Figure 36.

The Fortyfive River granodiorite extends east from the Fortyfive River area, and includes the pluton named the West River Sill by Ruitenberg *et al.* (1979). It is a distinctive altered pink-green hornblende-biotite granodiorite, as described by Barr and White (1988c).

A previously unmapped pluton, herein named the **Kent Hills granodiorite**, underlies the central part of the map area. It is mainly hornblende-biotite granodiorite, very similar to the Fortyfive River pluton, with which it is inferred to be correlative. This pluton extends across Caledonia Mountain to the eastern margin of the Highlands. Its northern margin is strongly sheared, and appears to be faulted against Unit Aar. However, the

contact with Unit Ahf appears to be intrusive, based on widespread contact metamorphism in adjacent metasedimentary/metavolcanic units.

The **Point Wolfe River Pluton**, largest in the Caledonian Highlands, extends into the northwestern part of the map area; part of this area was termed the Newman Brook Stock by Ruitenberg *et al.* (1979). It consists of two parts; an eastern half, consisting of granite, which is the extension of the Blueberry Hill granite of the Point Wolfe River Pluton, and a western part that is an extension of quartz monzodiorite and quartz diorite/tonalite units of the Point Wolfe River Pluton (Barr and White 1988*c*, 1989).

The **Caledonia Mountain stock** (Ruitenberg *et al.* 1979), a gabbroic intrusion, occurs in the northeastern part of the map area. The exposed area of this pluton appears to be less than indicated by Ruitenberg *et al.* (1979). A contact metamorphic aureole has been developed in metasedimentary and metavolcanic rocks in the vicinity of the intrusion.

The **Caledonia Brook pluton** (Ruitenberg *et al.* 1979) is located south of and in contact with the Caledonia Mountain gabbroic stock. A gabbroic dyke in the pluton near the contact indicates that the gabbro stock is younger. The Caledonia Brook pluton consists of relatively undeformed biotite-hornblende granodiorite.

To the south, complex elongate intrusions of diorite, granodiorite, and granite form the Caledonia Road, Crooked Creek, and Memel Creek sills, respectively, of Ruitenberg *et al.* (1979). These intrusions have complex field relations and distributions and cannot be subdivided on the scale of Figure 36, on which they are collectively called the **Caledonia Road granitoid suite**. Bodies apparently related to this suite are widely distributed in adjacent metasedimentary and metavolcanic units, but cannot be shown on Figure 36. The dioritic rocks are similar to and may be correlative with the Alma dioritic pluton (Figure 36), described by Barr and White (1988*c*).

CARBONIFEROUS ROCKS

Carboniferous rocks overlie the older rock units on the northern, eastern, and southern parts of the map area. In some areas these contacts are unconformities, but elsewhere they are faulted. On the southern margin of the map area, northeast of Alma, the rocks have been assigned to the Hopewell Group and Boss Point/Lancaster formations (Ruitenberg *et al.* 1979), whereas units of the Horton and Windsor groups occur along the eastern and northern margins (Ruitenberg *et al.* 1979; St. Peter 1989).

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A NEW U-PB DATE FOR THE FRENCH VILLAGE QUARTZ DIORITE, SAINT JOHN COUNTY, SOUTHERN NEW BRUNSWICK (C-NBCAMD)[34]

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The French Village Quartz Diorite has yielded a U-Pb (zircon) date of 537 ± 2 Ma, essentially identical to the date of 538 ± 2 Ma previously obtained from the Rockwood Park Granodiorite. These dates are consistent with the interpretation that plutons associated with the Brookville Gneiss and Green Head Group are younger than, and hence unrelated to, petrologically similar plutons of the adjacent Caledonia terrane.

La diorite quartzifère de French Village a révélé que l'U-Pb (zircon) avait un âge de 537 ± 2 Ma, ce qui est essentiellement identique à la datation de 538 ± 2 Ma obtenue précédemment pour la granodiorite de Rockwood Park. Ces datations sont conformes à l'interprétation selon laquelle les plutons associés au gneiss de Brookville et au groupe de Green Head sont plus jeunes que les plutons pétrologiquement similaires de la formation géologique adjacente de Calédonie, et que par conséquent, ils n'y sont pas reliés.

BACKGROUND

Plutons in the Saint John area of southern New Brunswick have been termed the Golden Grove Suite and generally considered to be Late Precambrian in age (*e.g.*, Wardle 1978; Currie *et al.* 1981; Currie 1984, 1987; Nance 1987; Williams *et al.* 1985). However, as a result of detailed mapping and petrological studies, Barr *et al.* (1990) and White *et al.* (1990) proposed that the term "Golden Grove Suite" be abandoned, on the basis that it includes rocks that are not intrusive, and that the plutonic components are unlikely to be part of a single intrusive suite, or to be of the same age. They assigned individual pluton names to units northeast of the city of Saint John (Figure 37), following, as much as possible, the long-established terminology of Hayes and Howell (1937) and subsequent workers in the area.

One of the plutons defined by White *et al.* (1990) is the French Village Quartz Diorite (Figure 37). The main pluton is well exposed along Highway 111, where it is in faulted contact with volcanic rocks of the Coldbrook Group. It has intrusive contacts with the Green Head Group, interpreted on the basis of the presence of numerous xenoliths of marble and quartzite throughout the pluton, and on the occurrence of a contact metamorphic aureole in the Green Head Group in the French village area. An intrusive relationship with the Brookville Gneiss is indicated by a small dioritic satellite intrusion in the gneiss west of the main pluton, and also by the occurrence of fine-grained dioritic dykes in the gneiss. The French Village Quartz Diorite was intruded by the Milkish head Pluton; contact relationships are well exposed in roadcuts on Highway 111.

AGE DATA

A sample for dating was collected from roadcuts on Highway 111 (Figure 37). It contained pale yellow to pale yellow-brown, euhedral zircon grains, many of which are broken fragments of large (+149 microns) grains. The original grains had length to breadth ratios of 15:1 to 5:1. The grains have fair clarity, numerous cloudy fractures parallel to 001 (perpendicular to the c-axis), and no visible zoning or cores.

[34]Contribution to the Canada - New Brunswick Cooperation Agreement on Mineral Development, 1990-1995. Project carried by the Geological Survey of Canada.

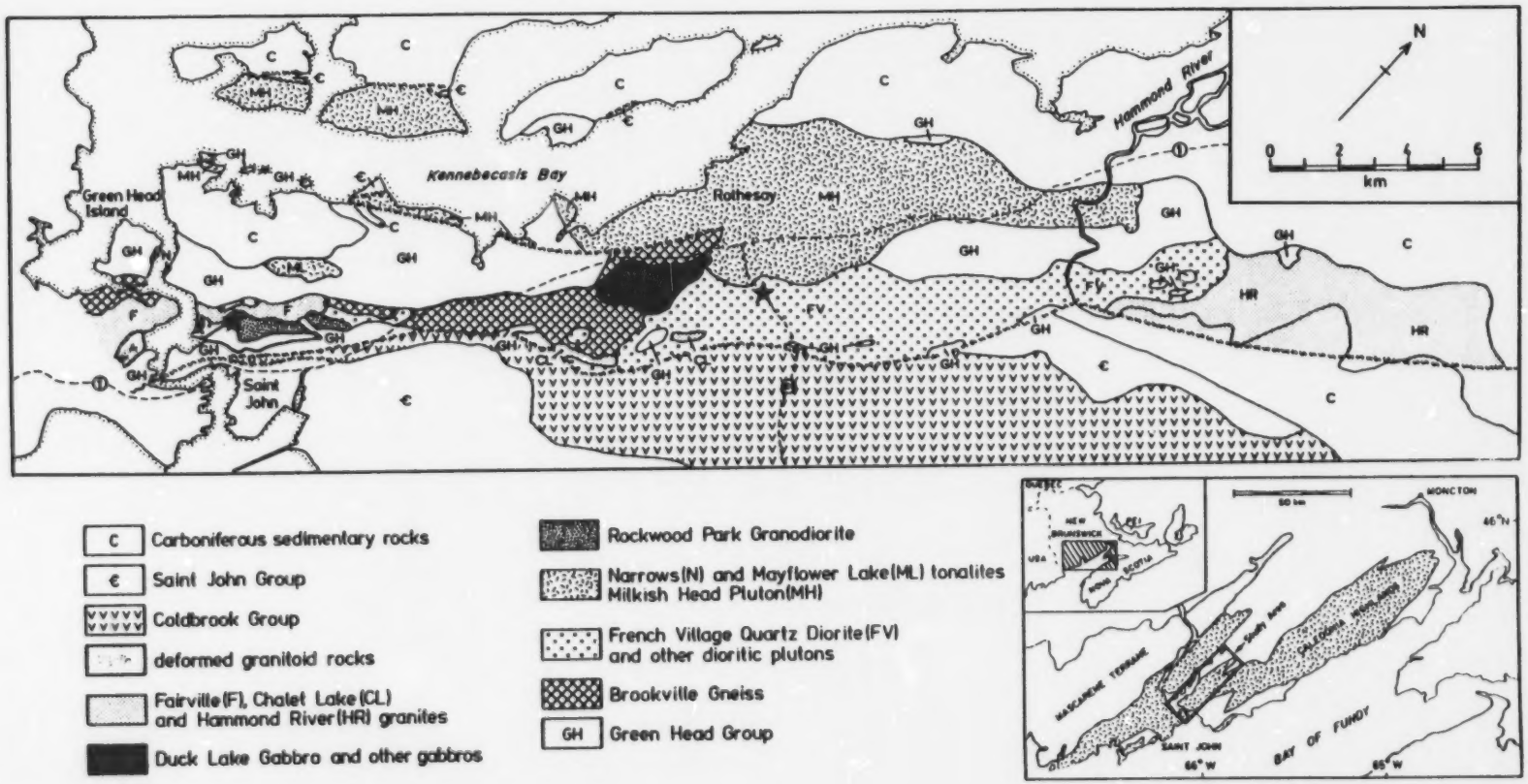

FIGURE 37. Detailed geological map of the Saint John area, east of the Saint John River showing the locations (stars) of the dated samples from the French Village Quartz Diorite and Rockwood Park Granodiorite (after White et al. 1990).

Of the three zircon fractions analysed, two fractions (A and B) are concordant and the other (C) plots just below concordia (Figure 38). A weighted average $^{207}Pb/^{206}Pb$ age for the concordant fractions is 537 ± 2 Ma, which we consider to be the best estimate of the crystallization age of the sample. Results for fraction C, which has a slightly higher $^{207}Pb/^{206}Pb$ age of 540 ± 2 Ma, probably reflects a combination of inheritance and lead loss.

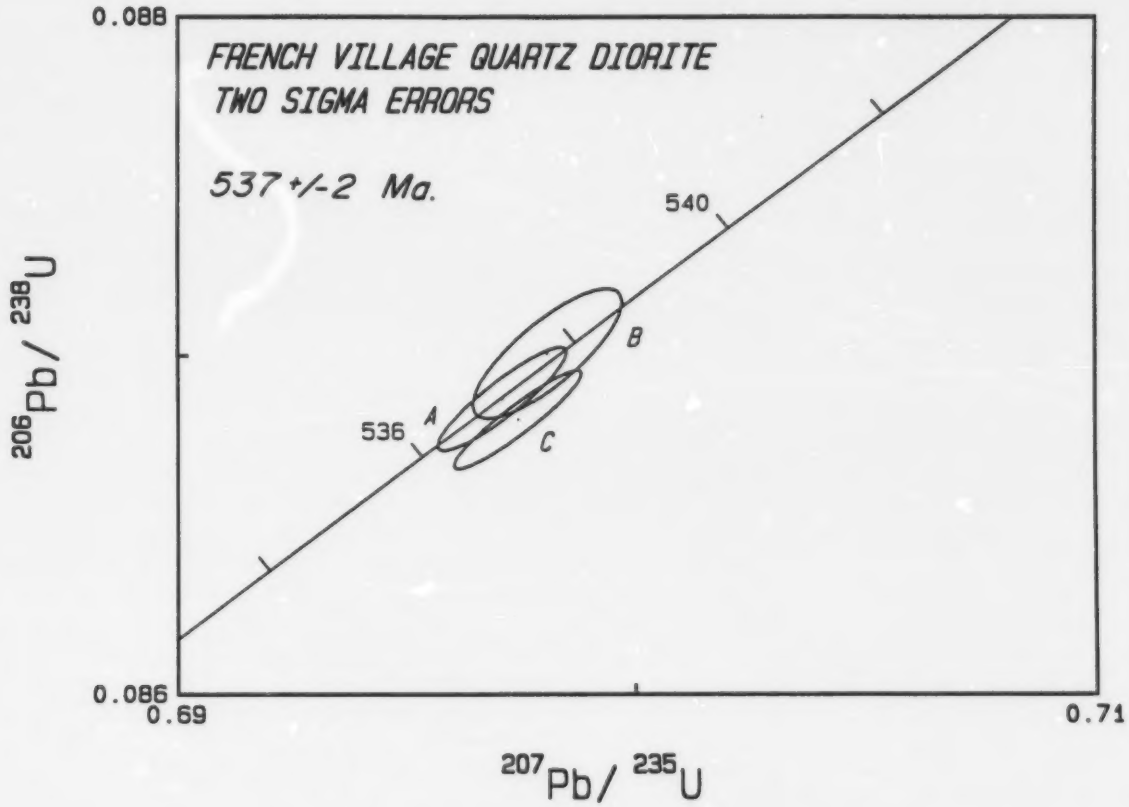

FIGURE 38. U-Pb concordia plot for the French Village Quartz Diorite, showing 2 sigma error envelopes.

IMPLICATIONS

The crystallization age of 537 ± 2 Ma for the French Village Quartz Diorite is essentially identical to the U-Pb (zircon) date of 538 ± 1 Ma reported by White *et al.* (1990) for the Rockwood Park Granodiorite (Figure 37). It strongly supports the contention by White *et al.* (1990) and White and Barr (1991) that plutons associated with the Green Head Group and Brookville Gneiss (Brookville Terrane of Barr and White (1989, 1991) are younger than plutons associated with the Coldbrook Group (Caledonia Terrane of Barr and White 1989, 1991). It is not certain whether these plutons are Late Precambrian or Early Cambrian in age, because the absolute age of the Precambrian-Cambrian boundary is controversial, with estimates ranging from ca. 570 Ma to ca. 530 Ma (Palmer 1983; Cowie and Johnson 1985; Odin *et al.* 1985)

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GÉOLOGIE DU QUATERNAIRE ET GÉOCHIMIE DES TILLS DES RÉGIONS DE BIG BALD MOUNTAIN (SNRC 21 O/1) ET DE SERPENTINE LAKE (SNRC 21 O/2), COMTÉS DE NORTHUMBERLAND ET DE VICTORIA, NOUVEAU-BRUNSWICK (ECCNBEM)[35]

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Les travaux de cartographie des formations quaternaires et l'échantillonnage servant à l'étude géochimique des tills s'est poursuivie pour une seconde année dans les régions de Big Bald Mountain (SNRC 21 O/1) et de Serpentine Lake (SNRC 21 O/2). L'échantillonnage des tills est complété et il respecte un espacement de un échantillon par 4 km². Les analyses géochimiques sont en cours. A l'extrémité est de la zone d'étude, de 5 à 8 mètres de sédiments stratifiés empriscnnés entre deux couches distinctes de till ont été observés dans deux coupes naturelles situées en bordure de la rivière South Sevogle et du ruisseau Mullin.

Quaternary deposit mapping and till sampling for geochemical studies in the area of Big Bald Mountain (NTS 21 O/1) and Serpentine Lake (NTS 21 O/2) was carried out during the second year of this program. The till sampling was completed using a 4 km² grid. The samples have been submitted for geochemical analysis. In the eastern margin of the study area, 2 tills separated by 5 to 8 m of stratified sediments have been observed along South Sevogle River and Mullin Creek.

Pendant l'été 1991, les travaux de cartographie des formations superficielles et l'échantillonnage des tills, pour des fins d'analyse géochimiques, se sont poursuivis pour une seconde année consécutive dans les régions de Big Bald Mountain (SNRC 21 O/1) et de Serpentine Lake (SNRC 21 O/2).

La région d'étude est localisée en majeure partie dans la zone tectonostratigraphique de Miramichi. Celle-ci comprend des roches métasédimentaires et métavolcaniques cambro-ordoviciennes du groupe de Tétagouche ainsi que des roches intrusives granitiques et gabbroïques ordoviciennes et dévoniennes. Des roches sédimentaires et volcaniques dévoniennes du groupe Dalhousie de la zone Tobique-Chaleur sont présentes dans la bordure ouest. La région d'étude et ses environs possèdent un potentiel minier intéressant et des gisements ou des indices minéralisés y sont déjà connus (Chester: Pb,Zn,Cu; Sheephouse Brook: Zn,Pb,Ag,Cu; Sevogle (Algoma): Pb,Zn,Ag; Sevogle (S.E.R.M.Ltee): Ag,Pb,Cu,Zn; Mountain Brook: Zn,Pb,Ag,Cu; Long Lake: Cu,Pb,Zn,Mo,Ag,Bi,Sn,U,Au; Mount Costigan: Zn,Pb,Ag,Cu,F; Heath Steele: Zn,Pb,Ag,Cu; Stratmat: Zn,Pb,Ag,Cu).

La cueillette des données de base nécessaires pour cartographier les formations superficielles à l'échelle du 1:50 000 est pratiquement complétée. Les cartes géologiques seront accompagnées d'un rapport où seront décrites les diverses unités observées et où sera présentée une interprétation de l'évolution paléogéographique au Quaternaire. Celle-ci incluera une description des écoulements glaciaires succesifs locaux et régionaux et du transport glaciaire qui en découle. La résultante de ce transport glaciaire a une incidence majeure sur la composition pétrographique des tills et évidemment sur les anomalies géochimiques que l'on peut y retrouver. Le rapport fournira également des informations relatives à l'utilisation du sol, à la disponibilité de ressources granulaires et à la sensibilité du terrain à certaines contraintes environnementales.

Les orientations des microformes d'érosion glaciaire relevées dans le cadre de ce projet sont similaires à celles observées antérieurement (Gauthier 1982; Rampton *et al.* 1984; Fyffe and Pronk 1985; Lamothe, sous-presse). En résumé, pour la carte de Serpentine Lake, les orientations des microformes révèlent des

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[35]Contribution à l'Entente de coopération Canada - Nouveau-Brunswick sur l'exploitation minérale, 1990-1995. Projet effectué par la Commission géologique du Canada.

écoulements glaciaires vers le sud-est et vers l'est. Sur la carte de Big Bald Mountain les microformes sont orientées dans une fourchette allant du nord-nord-est au sud-est. Dans le secteur nord-est de cette carte, les recoupements des microformes suggèrent que l'orientation de l'écoulement glaciaire s'est progressivement modifié depuis le N040° jusqu'au N100°, avec des intermédiaires plus marqués à N050°, N084°, et N095°.

En bordure est de la carte de Big Bald Mountain, deux tills séparés par des sédiments stratifiés sont exposés dans deux coupes distinctes. La première coupe est située dans un talus actif de la rivière South Sevogle. De la base au sommet, nous retrouvons : 3 mètres de till compact; 4 mètres de sable, de gravier et de blocs stratifiés (sédiments fluvio-glaciaires ou fluviatiles); 1 mètre de rythmites de silt argileux alternant avec des sables fins grossiers (sédiments glacio-lacustres proximal); 2 mètres de till compact. La seconde coupe est localisée dans un talus actif du ruisseau Mullin. On peut y observer, de la base au sommet : 2,5 mètres de till compact; 8 mètres de sable et de gravier stratifié (sédiments fluvio-glaciaires ou fluviatiles); 3,5 mètres de till compact. Ces deux coupes sont distantes de 2 km l'une de l'autre. Les données disponibles et l'absence de matériel datable dans les sédiments non glaciaires ne permet pas, pour l'instant, d'effectuer de correlations litho ou chronostratigraphiques. Ces séquences stratigraphiques pourraient être associées à la réactivation d'un lobe glaciaire lors du retrait final tardi-wisconsinien, il y a environ 13 000 ans (Rampton *et al.* 1984; Gauthier 1982; Lamothe, sous presse), ou pourraient être reliées à des événements antérieurs.

Dans le cadre de l'étude géochimique des tills, l'échantillonnage du till est complété pour les deux cartes et il respecte une densité de un échantillon par 4 km². Les analyses géochimiques pour 34 éléments traces sont en cours. Les banques de données seront publiés sous forme de dossiers publics dès que tous les résultats d'analyses seront complétées. Par la suite, des cartes d'abondance géochimiques seront produites. Une importance particulière sera accordée aux patrons de dispersion des anomalies géochimiques décelées dans les tills. Les observations et les interprétations obtenues par les études géologiques de base nous permettront déterminer les zones de provenance des constituantes du till, y compris les anomalies géochimiques.

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STRUCTURAL INVESTIGATIONS OF GOLD OCCURRENCES OF THE UPSALQUITCH FORKS AREA, RESTIGOUCHE COUNTY, NEW BRUNSWICK (C-NBCAMD)[36]

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In northern New Brunswick, gold occurrences of the Upsalquitch Forks area are spatially related to brittle-ductile deformation zones that occur along major and secondary faults related to the Rocky Brook-Millstream fault zone. Detailed studies of the Simpsons Field showing and the McCormack-Jonpol prospect reveal the existence of anastamosing fault zones and related isoclinal folds. Gold is found in association with brittle-ductile structures in mafic to felsic intrusive rocks of Silurian and/or Devonian age. Gold mineralization have been concentrated into the plumbing system formed by shear-related, open space veining. The compilation of fault slip data sets from both gold showings suggests a dextral rotation of stress tensors associated with transcurrent movements along the Rocky Brook-Millstream fault zone.

Dans le nord du Nouveau-Brunswick, les indices aurifères de la région d'Upsalquitch Forks sont spatiallement associés à des corridors de déformation fragile-ductile concentrés le long de structures, majeures ou secondaires, reliées à la zone de faille de Rocky Brook-Millstream. L'étude détaillée des indices de Simpsons Field et de McCormack-Jonpol a révélé la présence de failles anastamosées associées à des plissements isoclinaux. L'or est associé à des structures fragiles-ductiles au sein d'intrusions de composition mafique à felsique d'âge Silurien et/ou Dévonien. La minéralisation aurifère a été concentrée au sein d'un système de veines de remplissage associées à des cisaillements. La compilation de données structurales sur la cinématique des failles mineures mesurées sur les deux sites aurifères suggère une rotation dextre des tenseurs de contrainte induite par une tectonique décrochante le long de la faille de Rocky Brook-Millstream.

During the summer 1991, field work were conducted on gold showings of the Upsalquitch Forks area in northern New Brunswick (NTS 21 O/10). This study, which represents the continuation of a C-NBCAMD project (1990-95) initiated in 1990 (Tremblay and Dubé 1991) is mainly concerned with the nature of relationships between gold mineralizations and major fault zones in New Brunswick. In northern New Brunswick, gold occurrences are generally associated with subsidiary structures related to the Rocky Brook-Millstream fault zone (Tremblay and Dubé 1991).

The Upsalquitch Forks area has recently been mapped by Walker and McCutcheon (1991). Most gold occurrences of the area are found within mafic to felsic magmatic rocks, or at their contacts with Upper Silurian sedimentary rocks of the Chaleurs Group. U-Pb zircon age data from some of these intrusions yield an Upper Silurian to Lower Devonian age (McCutcheon and Bevier 1990). The best exposed gold occurrences in the Upsalquitch Forks area are the Simpsons Field and McCormack-Jonpol prospects, which are here used as case studies for the understanding of the lithological and structural context of gold mineralizations. Detailed field studies of the Simpsons Field and McCormack-Jonpol gold occurrences reveal a complex pattern of isoclinal folds and anastomosing brittle-ductile faults. The analysis of striated fault planes suggests a dextral rotation of stress tensors that occurred during transcurrent tectonism concentrated along the Rocky Brook-Millstream fault zone. Gold mineralizations appear to be associated with brittle-ductile structures related to dextral faulting along the Rocky Brook-Millstream fault. Gold is found in association with deformation zones and has been concentrated into a plumbing system formed by shear-related, open-space veining.

The Simpsons Field showing, located near the junction of the Ramsay Brook and the Portage Lake

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[36]Contribution to the Canada - New Brunswick Cooperation Agreement on Mineral Development, 1990-1995. Project carried by the Geological Survey of Canada.

faults, which are two subsidiary structures of the Rocky Brook-Millstream fault zone, is hosted by the Budworm City Formation. At the mineralized site, major structures seem to be related to competency contrasts among the various rock types and units. Gold occurs within veinlet stockworks at or near the contact between gabbroic intrusions and sedimentary host rocks. Veinlets are made up of pyrite-siderite-quartz-hematite and are found in both the gabbro and sedimentary host rocks. The structural analysis suggests that the stockwork is structurally controlled instead of hydrothermally driven. The stockwork is cut by the schistosity and seems to predate the regional folding of the area. Isoclinal east-plunging folds are faulted at the contact between gabbros and sedimentary rocks. By the compilation of striated planes around the Simpsons Field gold showing, a maximum stress tensor (σ_1) was calculated by the computed inversion method of Angelier (1984). These striated fault planes indicate a north-south–oriented compression vector (σ_1). σ_1 vectors calculated from the distribution of veinlets in the stockwork or from the schistosity trend are both subparallel to the σ_1 calculated by the Angelier's method. Mineralized stockworks are thus believed to be the product of a NNW-SSE–oriented compression vector whereas the regional folding and faulting appear to be related to a NNE-SSW compression vector. The variation of the σ_1 vector is attributed to a dextral rotation of regional compressive constraints induced by the Rocky Brook-Millstream fault.

The McCormack-Jonpol gold prospect is located on both sides of the McCormack Brook fault, a ENE-WSW–trending splay of the Rocky Brook-Millstream fault zone. The area is underlain by the Budworm City Formation, which is intruded by small plutons and sills of gabbro. Gabbros and related brecciated rocks are tightly folded with sedimentary rocks of the Budworm City Formation. Dragged and refolded folds are wedged along an anastamosing faults pattern. The structural analysis suggests that the mafic magmatism and related brecciation of host rocks occurred before the regional folding and faulting. Sedimentary clasts in breccias frequently show strongly perturbed primary laminations. Clasts are generally supported by a structureless silty matrix. We believe that a volcanism-related magmatism was the source of gold mineralization and also that it has been associated with the brecciation of hosting, unlithified and water-saturated sediments. In mineralized sites, gold is found in association with disseminated sulphides throughout altered intrusives and sedimentary rocks within brittle-ductile shear zones.

In the Upsalquitch Forks area, brittle-ductile fault zones appear to be almost synchroneous with regional deformation. Isoclinal, refolded, dragged folds and thrusts were developed during a continuous process of tectonic shortening. To accommodate late-tectonic compressive constraints, east-west–trending, dextral strike-slip faults, such as the Rocky Brook-Millstream fault, were activated and have reoriented pre-existing structures. The progressive rotation of compressive constraint vectors is in agreement with the transpressive tectonic regime attributed to pre-Carboniferous fault zones of northern New Brunswick (van Staal *et al.* 1990; Tremblay and Dubé 1991).

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PETROGENESIS, AGE, AND ECONOMIC POTENTIAL OF GABBROIC INTRUSIONS IN THE CALEDONIAN HIGHLANDS, KINGS COUNTY, NEW BRUNSWICK (C-NBCAMD)[37]

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Small plutons of mainly gabbroic composition in the Avalon terrane of southern New Brunswick and southeastern Cape Breton Island are being studied in order to compare and contrast their age, petrology, petrogenesis, and economic potential. The largest of these intrusions is the Mechanic Settlement pluton in New Brunswick, a layered ultramafic to mafic intrusion with sulphide and platinum-group-element mineralization.

De petits plutons de composition principalement gabbroïque dans la formation géologique d'Avalon dans le sud du Nouveau-Brunswick et dans le sud-est de l'Île du Cap-Breton sont étudiés afin de comparer et de mettre en contraste leur âge, leur pétrologie, leur pétrogénèse et leur potentiel économique. La plus importante de ces intrusions est le pluton de Mechanic Settlement au Nouveau-Brunswick, une intrusion stratifiée ultramafique à mafique accompagnée d'une minéralisation d'éléments du groupe platine.

The petrogenesis, age, and economic potential of several gabbroic plutons in the Avalon terrane in southern New Brunswick and southeastern Cape Breton Island are being studied as part of the MSc thesis project of the senior author. The plutons in New Brunswick include the Mechanic Settlement, Duck Lake, and a small pluton south of Sussex, here termed the Devine Corner gabbro. On Cape Breton Island, the plutons include St. Peters, Baleine, Louisbourg, Black Rock, and Gabarus. All of these gabbroic plutons were mapped in detail and sampled during the summer of 1991. The purpose of this project is to compare and contrast the petrology and petrogenesis and to assess the economic potential of all these gabbroic intrusions, but this report includes only the plutons located in New Brunswick. They are of particular interest because of the known occurrence of platinum-group-element mineralization in the Mechanic Settlement pluton (Paktunc 1989).

The Mechanic Settlement Pluton consists of mafic and ultramafic rocks that include peridotite, troctolite, olivine gabbronorite, olivine gabbro, gabbronorite, norite, gabbro, and anorthosite. The pluton appears to be composed of at least three major units, each starting with a peridotitic layer that varies in width from at least 5 to 50 metres. However, poor exposure of the pluton and rarity of marker layers does not allow correlation of rock types from one end of the pluton to the other. Layering, rarely visible in outcrop, is defined by mineral layering and by interlayering of rock types, with individual layers up 10-15 cm in thickness. Layering is most obvious in more plagioclase-rich rocks; it strikes northeast and dips south-southeast. Rare dykes, mainly of dioritic composition and 15 to 30 cm in width, are present in the pluton. These dykes are oriented either parallel to joints or contacts of the different rock types, or approximately perpendicular to them. In a few places, sheared zones (3 to 5 m in width), are developed in both ultramafic and mafic rocks. The relationship of the gabbroic rocks to dioritic rocks exposed southwest of the main body of the pluton is not clear due to the poor exposure. However, the dioritic rocks may compose the upper part of the pluton.

Cumulate textures are well developed in most samples; cumulate phases include olivine, chromite, clinopyroxene, orthopyroxene, and plagioclase; intercumulus phases include orthopyroxene, clinopyroxene, plagioclase, phlogopite, biotite, and kaersutite. Grain size varies from fine to coarse. The abundance of hydrous minerals in both ultramafic and mafic rocks indicates the presence of water in the magma, and shows that crystallization probably took place under relatively high pressure.

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The Duck Lake pluton, located near the city of Saint John, consists of medium- to coarse-grained rocks that include plagioclase-bearing ultramafic rocks, clinopyroxenite, olivine gabbronorite, gabbro, anorthosite, and diorite. Most samples have cumulate textures; cumulate phases include olivine, spinel, clinopyroxene, plagioclase, and amphibole; intercumulus phases include clinopyroxene, plagioclase, and amphibole. The Duck Lake pluton appears to be a small layered intrusion similar to the Mechanic Settlement pluton.

The Devine Corner gabbro is a small intrusion composed entirely of fine- to medium-grained gabbro. Texture is hypidiomorphic to allotriomorphic and inequigranular and cumulate textures are not present. Clinopyroxene and plagioclase are the dominant minerals, with minor brown amphibole. The pluton appears to be homogeneous except for variations in grain size.

Additional studies of these plutons are in progress, and include dating by $^{40}Ar/^{39}Ar$ and U-Pb methods, and mineral and whole-rock chemical analyses.

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BOREHOLE GEOPHYSICAL MEASUREMENTS AT THE SEWELL BROOK MASSIVE SULPHIDE DISCOVERY, VICTORIA COUNTY, NEW BRUNSWICK (C-NBCAMD)[38]

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Multiparameter borehole geophysical measurements were made in five holes at the NovaGold Sewell Brook lead-zinc-copper massive sulphide discovery. The parameters logged included resistivity, induced polarization (IP), self potential (SP), magnetic susceptibility (MS), natural gamma ray spectrometry (NGRS), spectral gamma gamma (SGG), and temperature. Preliminary interpretation of the data indicates that accurate localization of economic sulphides in the drill holes can be achieved by the SGG measurements. Resistivity, IP and SP logs locate sulphide mineralization as well but do no correlate well with sulphide concentration. The conductivity of the sulphides is low because of the high content of sphalerite which is a poor electrical conductor. The NGRS data accurately map changes in lithology and alteration. Alteration in the host rock and in the mineralized zones is comprised mainly of chloritization, silicification and pyritization. NGRS data promise to be important for mapping these alterations and hence for mapping favourable horizons of sulphide mineralization. Because of the high thermal conductivity of the sulphides, especially sphalerite, the temperature and temperature gradients at this deposit are highly anomalous and could be useful as an exploration tool.

Des mesures géophysiques furent effectuées dans cinq forages d'exploration de la propriété à sulfures massifs de plomb, zinc et cuivre de NovaGold à Sewell Brook. Les paramètres géophysiques mesurés furent la résistivité, la polarisation provoquée (PP), la polarisation spontanée (PS), la susceptibilité magnétique (SM), la spectrométrie naturelle de rayon gamma (SNRG), la spectrométrie gamma-gamma (SGG) et la température. L'interprétation préliminaire des données démontre que la SGG localise avec précision les sulfures massifs dans les différents forages. La résistivité, la PP et la PS permettent également de localiser les sulfures mais il n'existe pas une bonne corrélation entre ces paramètres et la concentration des sulfures. La conductivité des sulfures est faible parce qu'il y a une forte concentration de sphalérite qui est un pauvre conducteur. Les données de SNRG délimitent avec précision les changements lithologiques et l'altération qui consiste principalement en une chloritisation, silicification et pyritisation de la roche hôte et des zones minéralées. Les données de SNRG promettent donc d'être utiles pour cartographier les zones d'altération, et par le fait même, les horizons de minéralisation en sulfures. La température et le gradient de température pourraient être de très bons outils d'exploration parce que la conductivité thermique des sulfures présents dans ce gisement (particulièrement la sphalérite) est caractéristiquement élevée et présente de fortes anomalies.

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[38]Contribution to the Canada-New Brunswick Mineral Development Agreement, 1990-1995. Project carried by the Geological Survey of Canada.

FACIES RELATIONSHIPS WITHIN IRON FORMATION ASSOCIATED WITH MASSIVE SULPHIDE MINERALIZATION IN THE BATHURST AREA, NORTHERN NEW BRUNSWICK (C-NBCAMD)[39]

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In the Bathurst area, iron formation is spatially and temporally associated with massive sulphide mineralization. Geological and mineralogical characteristics of this iron formation have been studied in the vicinity of the Brunswick #12 deposit. Sulphide, carbonate (siderite), oxide (magnetite), and silicate (chlorite) facies are recognized. The distribution of these facies is complex and may be due to fluctuating physico-chemical conditions of precipitation and/or subsequent structural deformation.

Dans la région de Bathurst, une formation ferrifère est spacialement et temporellement associée à une minéralisation massive de sulfures. Les caractéristiques géologiques et minéralogiques de cette formation ferrifère ont été étudiées à proximité du gisement Brunswick n° 12. Les faciès du sulfure, du carbonate (sidérose), de l'oxyde (magnétite) et du silicate (chlorite) sont reconnus. La répartition de ces faciès est complexe et elle peut être due aux conditions physicochimiques variables de précipitation ou de déformation structurale subséquente.

INTRODUCTION

During the summer of 1991, a Canada-New Brunswick Cooperation Agreement on Mineral Developn (C-NBCAMD: 1990-1995) study of the sedimentology, mineralogy, and geochemistry of iron formation associated with massive sulphide deposits of the Bathurst area, northern New Brunswick was initiated.

The Bathurst area is underlain by the Tetagouche Group, a Cambro(?)-Ordovician sequence of metasedimentary and bimodal metavolcanic rocks that was intruded by mafic to felsic plutons and subsequently deformed during the Taconic Orogeny (van Staal 1987). The stratigraphic sequence consists of shales and greywackes that are overlain by carbonaceous shales, felsic volcanic and volcaniclastic rocks; these are in turn overlain by mafic volcanic and sedimentary rocks. The massive sulphide deposits and associated iron formations occur within the upper portions of the felsic volcanic rocks in close association with carbonaceous metasedimentary footwall rocks.

Iron formations associated with massive sulphides have been interpreted to be a chemical sediment deposited from hydrothermal fluids that vented into a submarine basin (*e.g.*, Stanton 1976*a*, *b*; Graf 1977, 1978; Stanton and Vaughan 1979). The principal objectives of the study are to determine the stratigraphy within the iron formation; document sedimentary structures and textures, vertical and lateral facies changes within the iron formation; and determine the effects of structural and metamorphic overprinting on the primary sedimentary and diagenetic features. Structural and stratigraphic complexities, combined with lack of outcrop, have hindered the exploration for massive sulphide deposits in the Bathurst district. A stratigraphic and geochemical model for the genesis of the iron formation will provide a better understanding of the processes by which elements were distributed on the paleo-seafloor during hydrothermal venting in the Bathurst area. This is of use in the exploration for concealed massive sulphide deposits. For example, the geochemical variability of the iron formation may serve as a vector that can aid in defining centres of hydrothermal venting and attendant massive sulphide mineralization.

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[39]Contribution to the Canada - New Brunswick Cooperation Agreement on Mineral Development, 1990-1995. Project carried by the Geological Survey of Canada.

PREVIOUS WORK

Previous petrographic and geochemical investigations of iron formation associated with massive sulphide mineralization in the Bathurst area include those of Bhatia (1970), Davies (1972), Whitehead (1973), Graf (1975) and Saif (1980, 1983). Saif (1980) recognized the following facies: 1) massive sulphide; 2) cherty-magnetite iron formation; 3) iron-rich chloritic rocks; and 4) iron-rich carbonate rocks. However, he did not investigate their spatial relationships and the possible existence of geochemical trends within the iron formations.

METHODS

Studies during the 1991 field season were concentrated on the Brunswick #12 deposit and its environs. Work included: detailed logging and sampling of diamond-drill cores that intersected sulphide and iron formation. Sampling encompassed the Brunswick #12 deposit and the iron formation for an along-strike distance of about three kilometres to the south and two kilometres to the north. More than 200 samples were collected from drill core, underground and surface exposures. Due to the structural complexity of the area (van Staal 1985), samples were taken only from intersections where the primary relationships between massive sulphides, iron formation, and hangwall and footwall lithologies are unambiguous.

RESULTS

Several facies of iron formation are recognized: 1) sulphide; 2) siderite-chert; 3) magnetite-chert; and 4) chlorite. The boundary between individual facies is only rarely sharp, and in most cases is gradational. Additionally, there also exist gradational boundaries or transition zones between iron formation and underlying and overlying rocks such as rhyolite tuff and hangingwall metasediments, respectively. Commonly, mixtures of several facies of iron formation are present (*e.g.*, magnetite-chert-siderite). For the most part, all iron formation facies are fine to very fine grained, but coarser beds are rarely present, and these are thought to represent incorporated detrital clastic, or tuffaceous material.

The following is a description of the iron formation facies that are recognized:

1) massive sulphide (sulphide facies) contains variable amounts of pyrite, pyrrhotite, sphalerite, galena, chalcopyrite, quartz, calcite and other minor sulphide and gangue minerals. Much of this material displays conspicuous banding. However, no textures that could be unambiguously interpreted as primary laminations were observed. Other common textures include brecciation (fragments of pyrite within a pyrrhotitic matrix) and recrystallization.
2) siderite iron formation (carbonate facies) is tan to grey coloured, and consists of alternating laminae of chert and siderite. Transitional material can contain laminae of magnetite and/or chlorite.
3) magnetite iron formation (oxide facies) is dark grey coloured, with alternating laminae/beds (<0.1 mm to ~2 cm) of magnetite and chert and, in places, pyrrhotite. Red hematite and hematitic quartz is exceedingly rare in this unit in the Brunswick #12 mine, and its presence is usually attributable to the presence of post-deformational quartz-calcite veinlets. In places, secondary, euhedral pyrite porphyroblasts occur within the siderite laminae. Transitional material can also contain laminae of chlorite and/or siderite.
4) chlorite iron formation (silicate facies) is deep to dark green-black in colour, nil to strongly schistose, and consists of felted to massive to laminated (faintly visible) fine-grained chlorite, with minor chert laminae and/or pyrite, pyrrhotite, sphalerite, and galena in layers, blebs, or porphyroblasts. Transitional material can contain laminae of siderite and/or magnetite.

Rip-up clasts consisting of clasts of chert and/or siderite have been noted within chlorite iron formation. Some intersections of chlorite iron formation contain graded bedding, consisting of silt to mud-sized detrital(?) quartz grains. In a few places, erosional contacts (scours) between two facies were noted. Additionally, pebble dents are also noted.

Correlation of beds and laminae within the iron formation between adjacent intersections was attempted but this was not successful. In some places, there is extreme variability in the iron formation types (facies) between adjacent drill holes. Additionally, many drill holes failed to intersect iron formation even in the

immediate vicinity of the Brunswick #12 deposit. This may be a primary feature due to the presence of multiple hydrothermal vent sites resulting in abrupt facies changes over relatively limited lateral distances, or it may be due to complications arising from structural deformation (folding and faulting).

A model for the zonation of iron formation facies within a basin has been presented in the benchmark paper by James (1954). This zonation is, from bottom to top and laterally outward, sulphide, to carbonate, to oxide, to silicate facies. Attempts were made to interpret the Bathurst iron formation in the context of this model. In a few places, where all facies are present, the stratigraphy within the Bathurst iron formation is broadly similar (*i.e.*, from footwall to hangingwall and stratigraphically upwards: massive sulphide, siderite, magnetite, chlorite). However, one or several of these facies may be absent, or the order of two facies may be inverted/reversed, or the entire iron formation interval may be a complex mixture of siderite, chlorite and chlorite. Such mixtures may be symptomatic of wildly fluctuation physicochemical conditions of mineral precipitation.

CONCLUSIONS AND FUTURE WORK

At present, laboratory work is focussed on detailed mineralogy (reflected and transmitted light microscopy, electron microprobe), lithogeochemistry, and sulphur, carbon and oxygen isotope analysis of sulphide and carbonate mineral phases. Field work for the upcoming 1992 field season will examine the iron formation outside of the Brunswick #12 mine area. Areas that will receive particular attention are Austin Brook, Brunswick #6, Flat Landing Brook, and Heath Steele.

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APPLICATION OF THE DECISION-TREE APPROACH TO MAPPING REGIONAL MINERAL POTENTIAL IN NORTHERN NEW BRUNSWICK: AN ALTERNATIVE TO WEIGHTS OF EVIDENCE (MDA & C-NBCAMD)[40]

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As more and more regional geoscience data becomes available in digital format, computer-based tools for integrating maps and images will be increasingly useful in mineral resource assessment. Geographic information systems (GIS) can play an important role at various stages of the data integration process. GIS not only allow the capture and storage of a variety of data types (raster images, maps digitized in vector format, point data with attributes) in a spatially referenced database, they also provide tools for deriving and extracting map patterns, for multi-map modelling operations, and for visualizing and interrogating results. More importantly, they can act as an intermediate step between a spatial database and other programs, such as packages for exploratory spatial data analysis, statistical analysis, and expert system applications.

Several methods have been used for combining maps to predict mineral potential. They can be broadly subdivided according to whether they are data-driven or knowledge-driven. In the latter, predictor maps are combined using the opinion of an expert; in the former, a predictive map is produced more objectively by using an inductive model based on the measured association between areas with known mineralization (the response variable) and the predictor maps.

For an area northwest of Bathurst (Figure 39), New Brunswick, regional data from ground-based geology, stream-sediment and till geochemical and airborne geophysical surveys with airborne radar and satellite TM (Thematic Mapper) imagery in a variety of digital formats have been integrated with a desktop GIS (Watson and Rencz 1988; Watson *et al.* 1989). Assessment of regional mineral potential was carried out using a data-driven modelling approach termed Weights of Evidence, WOE (Agterberg 1989; Bonham-Carter *et al.* 1989; Watson and Rencz 1989). This approach involves first simplifying each of the individual multi-class map layers by thresholding at a cutoff chosen to optimize the spatial association between the map patterns and the location of known mineral occurrences. In this manner, each component map was converted to a simplified binary or two-class representation. A method using conditional probabilities and Bayes' Rule was used to develop a weighting scheme for combining these simplified maps to produce a map showing areas relatively favourable to the occurrence of mineralization. This method is discussed in Bonham-Carter *et al.* (1988). The results were evaluated with respect to estimation error and uncertainty (Watson and Rencz 1990).

One of the essential conditions to weights of evidence modelling is conditional independence between data sets. Our analysis indicated, however, that significant dependence exists between many of the data layers from the study area. This was particularly the case between different map layers portraying features common to a given data type. For example, all four of the chemical elements that were found to be significant predictors of mineralization in till samples (Au, As, Cr, Ni) were very dependent upon each other. This situation required the elimination of some layers of data and various combinations of others in order to satisfy the independence requirement and to avoid artificially enhancing the relative favourability of some map areas. It is probable that this situation of interdependence, rather than independence, will prevail in many resource modelling cases.

In order to avoid the concern of conditional independence, another data-driven technique referred to as Decision-tree analysis (DTA) has been studied. Decision trees have been informally used for represent-

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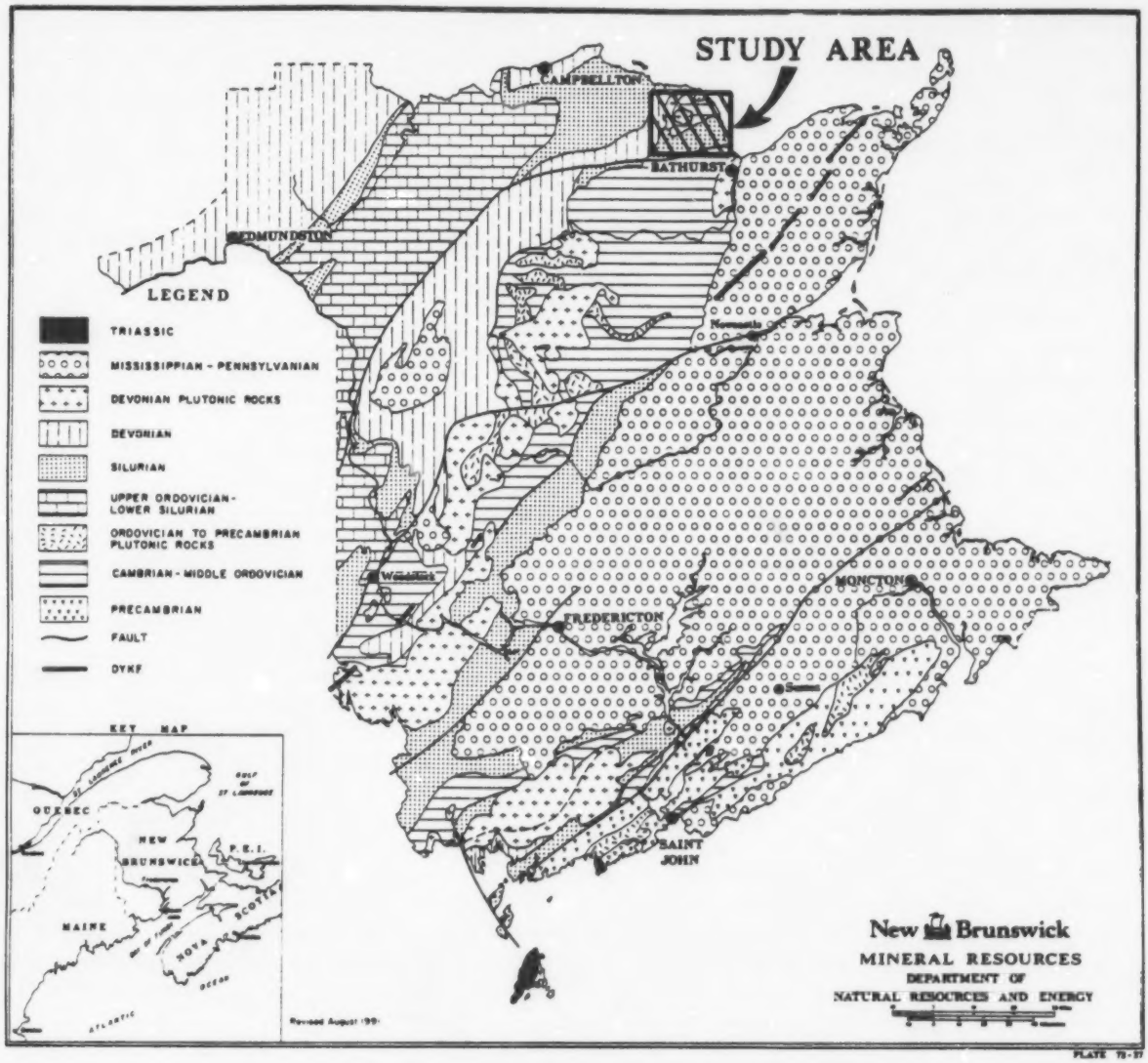

FIGURE 39. Location of project area in northern New Brunswick.

ing knowledge in a variety of natural science fields; identification of botanical taxa using "flora" is a classic example. Methods for building decision trees automatically have been described in the literature since the early 1960s. Recently, de Ville (1990) and Biggs *et al.* (1991) described a method that has been incorporated into a software package called Knowledge Seeker (KS) (FirstMark Technologies Ltd. 1990), which we have employed for this study.

The goal of DTA is to partition the dataset consisting of a response variable Y and n predictor variables, X_1, X_2, ...X_n, using one predictor variable at a time, so as to produce mutually exclusive and exhaustive subsets. It is similar to cluster analysis, but instead of lumping cases together, groups of cases are split apart; and intergroup differences are evaluated with respect to the response variable instead of using a similarity measure based on the predictor variables. The individual maps to be integrated are represented as predictor variables, while the mineral occurrence locations, in relation to each map layer, are used as the response variable. This is carried out by the built-in ability of the GIS software to examine concurrently the entire stack of map layers and portray the overlapping relationships between the layers as an overlay map and associated ASCII format table termed the 'unique-conditions report'. The location of mineral occurrences is appended to the ACII report in a

number of deposits per unique polygon format. A set of logical rules is developed from this database by the Knowledgeseeker program and reproted as a series of "IF.....THEN" conditional statements. These rules are then used in the GIS to create a relative occurrence density map, which is then interpreted as a mineral resource potential map. A detailed account of the mineral resource assessment with Knowledgeseeker is given in Reddy and Bonham-Carter (1991).

Both Weights of Evidence and Decision Tree Analysis approaches result in maps that define portions of the study area with relatively high, moderate, and low favourability of containing mineralization. The predictive maps from the two approaches were compared by overlay analysis within the GIS and an integrated favourability map was created.

Decision trees offer an alternative tool for examining predictive relationships in GIS-derived databases. They are attractive because they can be used with datasets containing mixed categorical and interval-scale variable, because they do not assume multivariate normality or conditional independence of variables, and because they produce as output an easily understood knowledge-base of decision rules (Reddy and Bonham-Carter 1991).

APPLICATION DE L'APPROCHE DE L'ARBRE DE DÉCISION À LA CARTOGRAPHIE DU POTENTIEL MINÉRAL RÉGIONAL DU NORD DU NOUVEAU-BRUNSWICK : UNE SOLUTION AU POIDS DE LA PREUVE (ECCNBEM)

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À mesure que de plus en plus de données géoscientifiques régionales deviennent disponibles sous forme numérique, les moyens informatiques pour intégrer les cartes et les images s'avèrent de plus en plus utiles pour l'évaluation des ressources minières. Les systèmes d'information géographique (SIG) peuvent jouer un rôle déterminant aux divers stades du processus d'intégration des données. Les SIG permettent non seulement la saisie et le stockage de toute une variété de types de données (images matricielles, cartes numérisées sous forme vectorielle, données point par point avec attributs) dans une base de données à repérage spatial, mais elles fournissent également des moyens pour obtenir et extraire des dessins des cartes, pour effectuer des opérations de modélisation multicartes et pour visualiser et interroger les résultats. Et surtout, ils peuvent servir d'étape intermédiaire entre les bases de données spatiales et d'autres programmes, notamment les progiciels destinés à des applications d'analyse des données spatiales exploratoires, d'analyse statistique et de systèmes experts.

Différentes méthodes ont été utilisées pour combiner des cartes en vue de prédire le potentiel minéral. On peut les subdiviser grossièrement selon qu'elles sont axées sur les données ou les connaissances. Dans le second cas, les cartes prédictrices sont combinées en recourant à l'opinion d'un expert; dans le premier cas, une carte prédictive est produite plus objectivement au moyen d'un modèle inductif basé sur l'association mesurée entre des régions à minéralisation connue (la variable de la réponse) et les cartes prédictrices.

Des données régionales provenant d'études géologiques terrestres, d'études géochimiques des sédiments fluviatiles et des moraines et d'études géophysiques aériennes menées par imagerie obtenue par capteur à l'aide d'un radar aéroporté et d'un satellite dans toute une variété de formats numériques ont été intégrées à une table de travail SIG (Watson et Rencz 1988; Waston *et coll.* 1989) pour une région à proximité de Bathurst, Nouveau-Brunswick. L'évaluation du potentiel minier régional a été entreprise selon une approche de modélisation dirigée par les données appelée «Poids de la preuve» (PDP) (Agterberg 1989; Bonham-Carter *et coll.* 1989; Watson et Rencz 1989). Chacune des couches des cartes multiclasses a été convertie en une représentation simplifiée binaire ou à deux catégories par seuillage à une troncature choisie afin d'optimiser l'association spatiale existant entre les dessins des cartes et l'emplacement des venues minérales connues. Les cartes binaires ont été combinées selon

l'approche bayesienne afin de réaliser des cartes finales indiquant les régions relativement favorables à la venue de la minéralisation. Les résultats ont été évalués en tenant compte d'une marge d'erreur d'estimation et d'incertitude (Watson et Rencz 1990).

Une des conditions essentielles à la modélisation du poids de la preuve est l'indépendance conditionnelle qui existe entre les ensembles de données. Notre analyse indique cependant qu'une importante dépendance existe entre un grand nombre de couches de données provenant de la région étudiée. Cette dépendance a particulièrement été présente entre les différentes couches cartographiques montrant des caractéristiques communes à un certain type de données. Par exemple, les quatre éléments chimiques reconnus comme des prédicteurs significatifs de minéralisation dans les échantillons de moraines (Au, As, Cr, Ni) dépendaient étroitement les uns des autres. Une modélisation solide nécessitait l'élimination de certaines couches et de diverses combinaisons d'autres afin de satisfaire l'exigence de l'indépendance. Il est possible que cette situation d'interdépendance, plutôt que de dépendance, prédominera dans un grand nombre de cas de modélisation des ressources.

Afin d'éviter la préoccupation par rapport à l'indépendance conditionnelle, une autre technique dirigée par les données, appelée Analyse de l'arbre de décision (AAD), a été étudiée. Les arbres de décision ont été utilisés de façon informelle pour représenter les connaissances dans toute une variété de domaines des sciences naturelles; l'identification des espèces botaniques à l'aide de la «flore» en est un exemple classique. Les méthodes de construction automatique des arbres de décision sont décrites dans des documentations depuis le début des années 1960. De Ville (1990) et Biggs *et coll.* (1991) ont récemment décrit une méthode qui a été incorporée à un progiciel appelé «Knowledge Seeker» (KS) (FirstMark Technologies Ltd. 1990), et que nous avons employée pour les besoins de la présente étude.

L'AAD a pour objectif de segmenter l'ensemble de données composé d'une variable de réponse Y et de n variables de prédicteurs X_1, X_2,... X_n, en utilisant une seule variable de prédicteur à la fois, afin de produire des sous-ensembles mutuellement exclusifs et exhaustifs. Elle est analogue à l'analyse des grappes, mais plutôt que de regrouper les cas, les grappes de cas sont fragmentées; les différences intergroupes sont ensuite évaluées en fonction de la variable de réponse au lieu de recourir à une mesure de similitude basée sur les variables de prédicteur. Chacune des cartes à intégrer est représentée comme une variable de prédicteur, tandis que les emplacements des venues minérales, se rapportant à chaque couche cartographique, sont utilisés comme variables de réponses. Cette opération est exécutée par la fonction de recouvrement sur le SIG qui identifie tous les «polygones uniques», représentée comme carte de recouvrement et associée au «rapport de conditions uniques». L'emplacement des venues minérales est annexé au rapport ACII dans un certain nombre de gisements par une forme polygonale unique. Un ensemble de règles du progiciel KS sont élaborées à partir de cette base de données, et elles sont recartographiées sous forme de carte des densités relatives des venues, ensuite interprétées comme carte du potentiel des ressources minérales. Un compte rendu détaillé de l'évaluation des ressources minérales réalisée à l'aide du logiciel KS est présenté dans le rapport de Reddy et Bonham-Carter (1991).

Les deux approches, PDP et AAD, donnent des cartes définissant des portions de la région étudiée en précisant la probabilité relativement élevée, moyenne et faible de minéralisation. Les cartes prédictives ont été comparées par l'analyse des recouvrements au sein de SIG et une carte intégrée de probabilité a été réalisée. Les arbres de décision offrent une solution de rechange pour l'examen des rapports prédictifs dans les bases de données obtenues par le SIG. Ils sont intéressants parce qu'ils peuvent être employés avec des ensembles de données contenant des variables mixtes de catégories et d'échelles d'intervalles, parce qu'ils n'assument pas de normalité multivariée ni d'indépendance conditionnelle de variables, et parce qu'ils produisent finalement une base de connaissances de règles décisionnelles facilement compréhensibles (Reddy et Bonham-Carter 1991).

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PART III

UNIVERSITY OF NEW BRUNSWICK

REPORT OF ACTIVITY, DEPARTMENT OF GEOLOGY AND GEOLOGICAL ENGINEERING PROGRAM, UNIVERSITY OF NEW BRUNSWICK

H.W. Van de Poll
Chairman of the UNB Department of Geology

GENERAL

The Department comprises 15 full-time Faculty, 4 Post-doctoral Fellows, 1 Professor Emeritus, 1 Adjunct Professor, 2 Research Associates, 7 Technical Staff, 3 Secretarial Staff, 4 Job Development Program trainees, 11 full-time, and 2 non-resident PhD candidates; 12 full-time, and 2 non-resident MSc students; 77 Undergraduate Students (25 science majors in geology and 52 geological engineers). In addition Dr. R.F. Miller, Head of the Natural Sciences Division, New Brunswick Museum, Saint John, has recently joined the Department as an Adjunct Professor.

The Natural Sciences and Engineering Research Council supported the Department's on-going research projects in the amount of $216 400 for operating and NSERC Matching/Partnership Industrial Funding of $36 500/ann. In addition, the Department continued work on a major research and development grant from the N.B. Department of Commerce and Technology. The sum of $380 501 was awarded for the purchase and operation of a CARIS workstation. Other financial partners in the CARIS venture are the University of New Brunswick ($87 855, mainly in kind), Potash Company of America ($20 000), and Universal Systems Ltd. ($39 460). In addition to the SUN workstation purchased from the above grant, a SUN IPC was donated by SUN Microsystems of Canada Ltd. for educational purposes ($19 000). The Maritime Provinces Higher Education Commission provided $62 036 for building renovations during 1991-92 ($49 950 toward the purchase of ten new research/teaching microscopes). Research contract for varying periods were negotiated, including various projects with the Geological Survey of Canada ($127 332), Energy, Mines and Resources Canada (14 677), Lithoprobe ($70 000/ann.), Shell ($14 000, two-year funding) Brunswick Mining & Smelting ($19 000/ann. for two years), Heath Steele Mines ($17 500), NBDNRE ($7500), and smaller amounts from the University of New Brunswick Research Fund ($10 000), Chevron ($500), AMOCO Canada Petroleum Company Ltd. ($1500), Challenge '91 ($4006), and others.

Four geologists and four geological engineers graduated from UNB since our last report. One PhD and two MSc degrees were awarded at Encaenia. Mr. David Huntley and Mr. Jeffrey Bellen were this year's recipients of the W.J. Wright Fellowship. The GAC/MAC Fredericton '85 prize recipient this year was Mr. Christopher Stanley. Sean McDonald was awarded the Frank S. Shea Memorial Award for the best economic geology paper at the AUGC meeting. Edwin van der Brand was the recipient of the Canadian Society of Petroleum Geologists Award. Rowena Gilbertson was awarded the Tractor & Equipment (1962) Ltd. Prize in Geology. Mr. Edward R.C. Hornibrook received the WAMIC (Women's Association of the Mining Industry of Canada Bursary).

All of our undergraduate students were able to obtain full-time employment this past summer. Several of our students worked on projects in New Brunswick (*i.e.*, NBDNRE, Brunswick Mining & Smelting, Heath Steele Mines, and other smaller, private organizations). Members of the faculty and graduate students published approximately 60 scientific papers and presented approximately 25 papers at various regional, national, and/or international meetings.

The CARIS project, jointly initiated and supervised by Drs. P.F. Williams and H.W. van de Poll, has been fully operative since January 5, 1991 when all the hardware was installed and renovations in the Department of Geology were completed. Its broad mandate is to expand CARIS-based research in applied geomatics in support of mineral exploration and development and geological mapping and research. Currently, three projects are planned or in progress:

1) Development of a field-based geological mapping module using CARIS,
2) Development of a relational database for the Lithoprobe transect in Manitoba, and
3) OCTREE for three-dimensional modelling.

1) Geological mapping module using CARIS. The purpose of this project is to greatly improve the quality and efficiency in the production of geological maps. With the introduction of the CARIS Geological Mapping Module, it will be possible to release a preliminary full-colour geological map to the user literally within minutes of returning from the field. Any changes from subsequent petrographic, lithogeochemical, palaeontological, microstructural work, age dating, etc. can be readily incorporated in the geological map at a later date as more information becomes available. Additional information from aerial and ground magnetometer surveys, V.L.F., soil geochemistry, satellite imagery, etc., at whatever scale, can be readily incorporated on the map either directly or as a series of overlays all of which can be issued in subsequent updated map releases. Printed (colour) maps will replaced by the instant electrostatic colour plotted map. In the not too distant future, the concepts of improved efficiency that we are developing into CARIS software will become increasingly affordable as the relative cost of hardware and software continue to decline. The user will be able to on-screen preview and select the seamless maps they need while waiting a few minutes for the most recently updated version to be printed.

2) The development of a relational database for Lithoprobe data. This project is still in its preliminary stages. Its objective is to develop CARIS software for the storage, management, integration, and retrieval of data in support of a large geological and geophysical project such as Lithoprobe. To achieve this it will be necessary to adapt and use specialized on-screen digitizing CARIS software (already completed), develop a data base, integrate hard copy maps with seismic data in digital form, project vertical seismic sections into horizontal geological maps and scan and store in digital form aerial photographs and reports so that the information can be readily accessed via an integrated computer network.

3) OCTREE for three-dimensional modelling. OCTREE is being developed to permit 3-D visualization and data entry of solid structures such as ore bodies, salt deposits, ground water aquifers, producing oil and natural gas fields, etc. A model of OCTREE is already in existence. It will ultimately make it possible to store and retrieve data on which to base ore calculations, ore control, mine layout, and planning optimization of selective mining, aquifer (flow rate) modelling, the design of underground waste-storage facilities, etc.

GEOLOGICAL ENGINEERING

Geological Engineering continues to be a popular program at UNB with approximately 42 undergraduates enrolled in all years. Ten students graduated from Geological Engineering this year an 12 new students entered the five-year programme at various levels from year one to year three. Almost every student from first year on was employed in geological work over the summer and this in itself is expected to have a positive impact on future enrolment in the program.

Dr. A. Valsangkar continues in his term as Director of Geological Engineering.

GEOCHEMISTRY

Dr. N.J. Susak is continuing research on the speciation of chromate and molybdenum in chloride solutions with Dr. D.A. Palmer and Dr. D. Wesolowski at Oak Ridge National Laboratory. Research on the speciation of cobalt and manganese in being done is collaboration with Dr. D.S. McClure, Dr. D.A. Crerar, and A. Henry of Princeton University. Work on a new program to determine stability constants from spectrophotometric data is in progress. The concentration solver subroutine should also be useful in geochemical reaction path modelling.

GEOPHYSICS

K. Burke spent a 6 months sabbatical leave at the DSIR Seismological Observatory in Wellington, New Zealand. He worked on a velocity - structure modelling project using an earthquake data set from a network

located over a part of the Hikurangi subduction zone. He also participated in the Hikurangi Margin Seismic Refraction Experiment along the east coast of New Zealand.

GLACIAL GEOLOGY

During 1990/91 the Glacial/Quaternary Group included: Dr. B.E. Broster; an undergraduate student/research assistant, Edward Hornibrook; two MSc Graduate students, Solweig Balzer and David Huntley; and Dr. Randy Miller, Head of the Natural Sciences Division of the New Brunswick Museum, recently appointed as an Adjunct Professor in the department.

The 1991 biennial conference of the Canadian Quaternary Association (CANQUA) was held at UNB in June. The conference was co-organized by B. Broster and T. Pronk (NBDNRE) and attended by approximately 70 people. A three-day field trip through southwestern New Brunswick was led by A. Seaman, T. Pronk, and J. Thibault of NBDNRE, Dr. L. Cwynar of UNB Biology, Dr. B. Broster, and Dr. R. Miller. Dr. Broster is currently Past President of CANQUA.

Dr. Broster's research continues to focus upon applications of glacial processes and products relative to exploration, environmental, and engineering activities. This year, research was started on glacial dispersion in New Brunswick, with W. Gardiner and T. Pronk of NBDNRE, and E. Hornibrook. Research projects were also started with Dr. A. Park (UNB Geology) on glacial deformation in the Boiestown area and at Heath Steele Mines.

Mr. E. Hornibrook completed his BSc thesis project on heavy mineral dispersion in till, Todd Mo[illegible] New Brunswick. This summer Mr. Hornibrook continued on a similar project in the Millville area thr[illegible] NBDNRE, with Dr. B. Broster, W. Gardiner, and T. Pronk. Reports of these activities are now available in NBDNRE Open Files.

Ms. S. Balzer completed field work on glacial stratigraphy, geochemical and lithological dispersion in the Canterbury Map Area as part of a DNRE regional mapping project with A. Seaman. The work is par[illegible] of an MSc project, supervised by Dr. Broster, which will form the major part of an Open File expected to be out in late spring 1992.

Mr. D. Huntley started a MSc project on glacial dispersion and stratigraphy on the Fraser Plateau, British Columbia, as part of a regional mapping project with the Geological Survey of Canada (GSC). The mapping will be undertaken in conjunction with a research contract between Dr. Broster and the GSC.

In July of this year Dr. Randy Miller, Associate Curator of Geology at the New Brunswick Museum, was appointed Adjunct Professor in the Department of Geology. The New Brunswick Museum houses one of the oldest geological collections in the country dating back to Abraham Gesner's museum which opened in 1842. The collection now contains more than 40 000 specimens including more than 1000 type fossils. As curator of the provincial collection Dr. Miller's interests include the study of Precambrian to Quaternary palaeontology in New Brunswick as it relates to the New Brunswick Museum fossil collection, the history of geoscience investigation in New Brunswick and the development of rock and mineral collections for the museum.

The primary research experience that Dr. Miller brings to the department is in Quaternary sciences, in particular, palaeoecology and palaeoclimate studies using insect fossils. The main focus of his current research is the Late Glacial Younger Dryas cooling event in the Maritimes and last interglacial-glacial in the Maritimes. Fossil insect studies in New Brunswick are being supported by the New Brunswick Museum while work in Nova Scotia is being conducted with financial support from the National Geographic Society. In addition to taxonomic studies of fossil beetles, Dr. Miller's research includes the development of stable isotope techniques to use fossil chitin as a palaeoclimatic tool. Some of this research is being conducted in collaboration with colleagues at the University of Liege (Belgium) and the Scripps Institution of Oceanography.

MINERAL DEPOSITS

Economic geology activity continued to be focused mainly on Appalachian mineral deposits with an emphasis on massive sulphides.

Dr. D.J. Bachinski continues his on-going studies on porphyry coppers. Dr. P.F. Williams and Mr. W. Roberts (recent MSc graduate) completed a study of the structure of the potash in the Dennison Mine at Sussex as an aid to mine safety and improved economic assessment of its potash potential.

Dr. Adrian Park, a Post-doctoral fellow along with Dr. P.F. Williams, is currently working at Stratmat in the Bathurst area. This is a collaborative project with Heath Steele Mines, DNRE and the University.

Dr. J.P.A. Noble with PhD graduate student, Mr. Ali Chowdhury, is continuing his project on the diagenesis and fluid history of the Albert Formation in the Moncton basin. Several publications relevant to future oil and gas exploration in New Brunswick are in preparation and follow-up studies are in the planning stage. Mr. Clint St. Peter, MSc candidate under the supervision of Dr. Noble, has just completed his study of the lithology and seismic facies of the Albert Formation with conclusions on the structural evolution, trap potential and subsurface distribution of the oil-bearing Albert Formation. A new student is expected to start work on this project shortly under the supervision of Dr. Noble.

Dr. J.G. Spray is currently supervising two graduate students (Jeff Bellen and Gordon Clarke) in mineralogical/petrological and geochemical studies of the 'new intersection' of massive sulphides discovered north of the Brunswick 12 orebody. This project is jointly funded by Brunswick Mining and Smelting and NSERC and is primarily aimed at: (1) more effectively targeting massive sulphide ore horizons through lithogeochemical studies; (2) identifying the protoliths of some of the more problematic lithologies and (3) relating the above to regional metasomatic and metamorphic processes and their structural controls.

At the annual GAC/MAC meeting held in Toronto in May (1991), Gordon Clarke gave a talk entitled "Deep exploration using lithogeochemistry: application to the North Extension of the Brunswick 12 massive sulphide orebody, Bathurst Camp, New Brunswick"; and Peter Banks gave a presentation entitled "Formation of the O'Toole nickel sulphide deposit and related metakomatiitic host, Fortaleza de Minas, Brazil" following completion of his BSc honours thesis on the electron microprobe analysis of selected ore minerals.

PALAEONTOLOGY

Dr. A. Logan is continuing actuopalaeontological studies of modern hard substrate communities in the Bay of Fundy with a view to ascertaining their value for palaeoecological reconstruction in the Mesozoic. Following completion of his project on competitive interactions of hermatypic corals in Bermuda, Dr. Logan has commenced a new NSERC supported study on growth rates of two species of hermatypic corals from Bermuda and Barbados. The purpose of this study is to determine the effects of depth and latitude on the growth rates of these corals as an aid in palaeoecological and palaeoclimatic determinations.

Dr. R.K. Pickerill is continuing work on the structure, composition, ecology and evolution of Silurian brachiopod-dominated communities of Arisaig (Nova Scotia). Additionally, he is making a study of the structure, composition and evolution of Ordovician marine benthic communities in Quebec with Dr. T.L. Harland and in Wales with Dr. P.J. Brenchley. He is also collaborating with Dr. M. Wade of the Queensland Museum, Australia, in a study of Cambrian jellyfish from the Saint John area. He continues his extensive trace fossil research in Spain, Portugal, Quebec, Newfoundland, New Brunswick, Alaska, Oregon, southern California, Jamaica and northern Greenland. Mr. D. Fillion, one of his PhD graduate students, is in the final stages of completing his studies in Oregon and southern California.

Dr. Noble is continuing his studies on the palaeontology of Silurian tabulate corals.

IGNEOUS PETROLOGY

During 1990/91, the Igneous Petrology group included Dr. Todd Dunn and two graduate students (Mrs. Suporn Intasopa - PhD candidate and Mr. Cuneyt Sen - PhD candidate). Mr. Waldo Perez joined the group in August 1991. Group activities during the year included analytical, experimental and field based research in various areas of Igneous Petrology and Geochronology. Projects included:

Group members completed four research projects that resulted in the submission of papers to major journals. Dr. Dunn used the new piston-cylinder apparatus to investigate the interactions between basaltic magma and lower crustal rocks. That project generated conclusive evidence for highly non-equilibrium and non-modal assimilation of the crustal rocks. The work has been submitted to the journal *Earth and Planetary Science Letters*. Mrs. Intasopa and Dr. Dunn completed a paper on the isotope geochemistry and petrology of the volcanic rocks in Loei province, Thailand. That work, which yielded a new model age for basement rocks of the western margin of the Indosinia cratonic block, has been submitted to the *Bulletin of the Geological Society of America*.

Mr. Sen and Dr. Dunn finally completed work on the detailed trace-element geochemistry of the minerals and their host lavas from Mr. Adams (Washington, USA). That project combined two state of the art analytical techniques (IPMA and ICP-MS) to generate a new comprehensive set of mineral/melt partition coefficients for anhydrous calc-alkaline rocks. The paper has been submitted to *Geochimica et Cosmochimica Acta*. Finally, Dr. Dunn and Mr. Sen, after much more probe work, have completed a paper, submitted to *Contributions to Mineralogy and Petrology*, on the ubiquitous augite xenocrysts found in Mt. Adams lavas. The xenocrysts were determined to be samples of older, widespread rhyolites and the upper mantle source region of the Mt. Adams basalts.

Research in progress includes collaborative work with Dr. A.J. Irving at the University of Washington (Seattle) and Dr. P. Kelemen of the Wood's Hole Oceanographic Institution on the partitioning behaviour of high field strength elements and the LREE in olivine and orthopyroxene melt systems. In addition, Dr. Dunn is collaborating with Drs. V.C. Kress and M. Ghiorso, University of Washington, in a study of major-element chemical diffusion in the CAS system. Dr. Dunn is doing high-pressure experiments to complement the one bar work being done in Seattle.

Mrs. Intasopa is continuing her isotopic work on the Central Thailand Volcanic Belt. This fall, she will be spending time at the University of Alberta where she will do Sr, Nd, and Pb isotopic work on a suite of her samples. That data should provide some very interesting information on the composition of the mantle beneath a continental suture zone. In addition, Mrs. Intasopa will be spending some time at the University of Maine to complete her $^{40}Ar/^{39}Ar$ dating work.

Mr. Sen has now started experiments for his thesis project on mantle metasomatism. He has completed preliminary work on the interactions between partial melts of amphibolites and spinal lherzolite. His results have demonstrated that melt metasomatism tends to eliminate augite from the mantle mineral assemblage and replace it with an amphibole. He is now designing new experiments to determine the trace-element chemistry of the fluids derived from amphibolites during high-pressure dehydration and dehydration melting.

The newest member of the group, Waldo Perez, arrived in Fredericton in August from Argentina. While in Argentina, he completed a field PhD on granite/wallrock interactions and crustal assimilation. During his PhD studies at UNB, he will be investigating the same types of interactions via experimental methods.

METAMORPHIC PETROLOGY

Dr. J.G. Spray is continuing his investigations of metamorphism and melting in fault and shear zones and on the generation and evolution of ophiolite complexes. The work on ophiolites is currently focusing on dynamothermal processes occurring within the crustal sequences and, in particular, the gabbros (equivalent to ocean layer 3) of selected Appalachian-Caledonian bodies in Canada and Scotland. Mr. James Whitehead has recently commenced a PhD project on this topic.

Experimental work continues to explore the mechanism of frictional fusion in geological materials using modified friction welding apparatus, whilst field work balances this with the mapping and sampling of natural fault and shear zones. High-grade metamorphism and anatexis is also being investigated as it pertains to plagiogranite generation in the ocean crust (*e.g.*, via studies of the Fournier and Shetland oceanic fragments).

Allied high-strain rate effects are being investigated with the help of two new students concerning : (1) shock- and fault-induced melting related to meteorite impact (Ms. Lucy Thompson working on the Sudbury Complex, Ontario) and (2) high-speed drilling and its effects on shale stability in oil and gas wells (Mr. Christopher Hawkes in collaboration with Shell).

MINERALOGY/CRYSTALLOGRAPHY

Dr. L.T. Trembath has been studying crystallization of feldspar in synthetic and natural systems in order to develop a better understanding of the crystallization and emplacement of granitoids.

The x-ray diffractometer has been automated with the data accumulation and reduction proceeding with minimal intervention by the operator. The A.S.T.M. database is held on a single CD-ROM disc. Identification of multi-phase mixtures has been automated to the point where an undergraduate student can reliably identify five or six minerals in a mixture often in less than five minutes. Powder diffractometer patterns can be calculated for any compound of known composition and structure. This permits identification of materials for which diffraction patterns are not currently available.

REGIONAL MAPPING PROJECTS

Several members of the Department continue to be active in regional studies. Professor I.M. Patel is working on the Precambrian-Cambrian boundary in New Brunswick. Dr. J.P.A. Noble is continuing his regional stratigraphic studies of the Silurian-Devonian of northern New Brunswick, while the stratigraphy, structure and associated igneous rocks of the Upper Devonian Perry Formation in southwestern New Brunswick and adjacent Maine are being investigated by Dr. P. Stringer, Dr. K.B.S. Burke and Dr. T. Dunn. The structure and extent of the early Jurassic Ministers Island dyke in southwestern New Brunswick and eastern Maine, and the mainland and offshore structure of the Triassic Lepreau Formation in southern New Brunswick, are being investigated by Drs. Stringer and Burke.

Dr. H.W. van de Poll continues his interest in applying specialized mapping techniques in his study of the Permo-Carboniferous of New Brunswick, and Prince Edward Island emphasizing the lithostratigraphy, sedimentology, and physical diagenesis of these strata for an overall analysis of the palaeogeographic palaeoclimatic and structural evolution of the Maritimes Basin during late Palaeozoic time.

Postgraduate students working under Dr. Williams' direction continue mapping in Cape Breton Island and in the Northwest Territories and have started mapping in the Flin Flon-Snow Lake area of Manitoba and the Monashee Complex of British Columbia.

SEDIMENTOLOGY

Dr. J.P.A. Noble is continuing his long-range sedimentological studies emphasizing the diagenesis and burial histories of sedimentary basins in northern New Brunswick and Gaspé. In particular comparisons of diagenesis in the basins and adjacent shelf borders, is shedding light on the structural and burial histories of these marginal zones. A similar, but much better exposed (and much better known stratigraphically) foreland basin in the Alps, is now being studied for the information it provides on the less well known Appalachian basins.

Dr. R.K. Pickerill, in addition to contributing sedimentological work to a regional study of the Saint John Group, is also continuing his extensive studies of Middle Ordovician sedimentation of the Trenton Group carbonates of Quebec. Three of his graduate students are involved in sedimentological studies in the Carboniferous of Cape Breton, Lower Devonian of central New Brunswick and Upper Ordovician of Ontario.

In addition to applying specialized sedimentological mapping techniques for regional Basin analysis, Dr. H.W. van de Poll and Professor I.M. Patel are continuing their studies on physical diagenesis. These studies concentrate on post depositional processes related to compaction of the sediments. Their findings suggest that many sedimentary features, including grain-matrix and clastic ratios and certain types of sedimentary structures may not entirely be the result of primary processes, but can also be attributed to secondary processes of sediment remobilization during compaction. This work is on-going in conjunction with Carboniferous Basin analysis and has potential applications in facies analysis, palaeoseismic interpretations, syndepositional tectonics and petroleum reservoir studies.

STRUCTURAL GEOLOGY

Dr. J.C. White continues studies of deep-crustal deformation: graduate student D. Jiang is examining chemo-mechanical processes in the deepest level décollement of the Parry Sound shear zone, Ontario and an EMR-supported project to characterize the chemo-mechanical nature of deformation and preservation of fine-grained granulite facies rocks in the Stony Rapids, Saskatchewan area was begun the past summer. Ultrastructure studies (SEM/TEM) of pseudotachylite and associated intracrystalline deformation from the Hebridean thrusts, Scotland and Vredefort complex, South Africa are in various stages of completion. Additionally, Vredefort rocks are being compared to prior studies of shock deformation from the Manicouagan structure in Quebec. An electron microscopical study of fine-grained Bathurst camp materials is in its early stages, but has indicated unexpected formation in veins of inclusion-rich untwinned K-feldspar suggestive of primary microcline; this remains to be verified by electron diffraction.

Dr. P.F. Williams and Dr. L.B. Goodwin, a post-doctoral fellow are involved in studying the faulting history of the Canadian Appalachians. Dr. Goodwin has focused on understanding the structural evolution of two major tectonostratigraphic terrane boundaries - commonly termed the Baie Verte and GRUB Lines - in Newfoundland. Her funding is provided through Lithoprobe. The main goal of the project is to provide geologic constraints on interpretations of seismic data obtained from the Lithoprobe East Transect. Additional objectives include (1) developing an understanding of the way in which structures develop in a ductile transpression zone, and (2) studying the deformation behaviour of anisotropic materials.

Dr. P.F. Williams is involved in two joint projects with the Geological Survey of Canada in the Northwest Territories. Two graduate students, Christopher Beaumont-Smith (PhD) and Robin Wyllie (MSc) are conducting structural mapping work around the Back River Complex and the Archaean rocks of the Bathurst Inlet area (NWT) respectively. GSC supervisors are Maurice Lambert and Jack Henderson, while Robin Wyllie's project also receives industrial funding.

Dr. A.F. Park (a post-doctoral fellow working with Dr. P.F. Williams) is working on a contract with Heath Steele Mines (a division of Brunswick Mining and Smelting) investigating the deformational history of the Stratmat Pb-Zn sulphide deposit, northern New Brunswick. This study involves the application of structural analysis to problems of sulphide genesis and deformation, exploration and ground control.

Dr. P.F. Williams and Mr. B. MacEachen have continued developing a field-based computerized mapping system using CARIS.

NEOTECTONICS

K. Burke and P. Stringer are completing an investigation of potentially neotectonic features in southwestern New Brunswick under a research agreement with EMR. K. Burke visited sites of active and earthquake-related faulting during a sabbatical leave in New Zealand to obtain a better perspective on local neotectonic features.

CENTRE FOR DEFORMATION STUDIES IN THE EARTH SCIENCES

Members of the Centre for Deformation Studies in the Earth Sciences (Broster, Burke, Spray, Stringer, van de Poll, White, Williams) have supported an array of research projects over the last year including a

significant number of meeting presentations (see reports by individuals and publication list). These projects comprise several collaborations among different members of the Centre with a growing emphasis on industry-university interaction. To this end, changes to enhance the profile of the Centre and improve access to researchers are underway in co-operation with the Research Services Office.

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PART IV

RESEARCH AND PRODUCTIVITY COUNCIL

MINERALOGY AND PROCESSING AT THE NEW BRUNSWICK RESEARCH AND PRODUCTIVITY COUNCIL

Compiled by Dave Desjardins

INTRODUCTION

The Research and Productivity Council (RPC) is a multidisciplinary science and engineering organization that offers its services to industry on a cost-recovery basis. Mineral-related activities are directed primarily in the disciplines of mineralogy and mineral processing. RPC offers a wide range of expertise in these disciplines through its staff of scientists and engineers. Activities during the past year carried out for the mining industry are as follows:

MINERALOGY

The activities in the mineralogy group were concentrated in the areas of petrographic and mineralogical analysis and interpretation, image-analysis application to solving mineral processing and metallurgical problems, and quantitative microprobe analysis of minerals, metals, and alloys. Project highlights for this year include:

(1) Detailed petrographic and mineralogical analysis of drill-core samples carried out for mineral exploration companies active in the Bathurst Camp, New Brunswick and Maine;

(2) A major image-analysis study has been initiated to test a novel approach to determine floatability of various minerals for the Kidd Creek Division of Falconbridge; and

(3) Routine petrographic investigation of concrete aggregate and geological supervision of crushed and natural aggregate sources for NB Power as part of the Belledune 450 MW Plant to assess soundness specifications and presence of alkali reactive components.

PROCESSING

Both hydrometallurgical and roasting projects provide the bulk of the work for our mineral processing group. Highlights over the past year include:

(1) Successful development of a ferric chloride leaching flowsheet that is now in the process of being piloted at RPC;

(2) Examination of processing alternatives for a secondary copper deposit;

(3) Application of high-temperature filtration technologies for particulate control on contract to Cominco and Inco; and

(4) Air-quality analysis and assessments for several mining companies in response to Occupational Health and Safety guidelines.